



# Reliability Analysis Update

Transmission Expansion Advisory  
Committee

January 11, 2018



# 2017 RTEP Analysis Update



# DPL/PECO Transmission Zone Final 2017 Window Recommendation

## Generation Deliverability (Summer) (GD-S798 and GD-S815):

### Problem Statement:

- The Edge Moor – Claymont – Linwood 230 kV circuit is overloaded for line fault stuck breaker contingency loss of the Edge Moor – Linwood 230 kV circuit and two units at Philips Island.

### Alternatives considered:

2017_1-9A (\$1.83 M)	2017_1-9H (\$55.7 M)
2017_1-9B (\$28.4 M)	2017_1-9I (\$64 M)
2017_1-9C (\$5.73 M)	2017_1-9J (\$37.69 M)
2017_1-9D (\$37.95 M)	2017_1-9K (\$9.58 M)
2017_1-9E (\$26.78 M)	2017_1-9L (\$1.4 M)
2017_1-9F (\$28.69 M)	2017_1-9M (\$8.37 M)
2017_1-9G (\$36.56 M)	2017_1-9N (\$79.03 M)

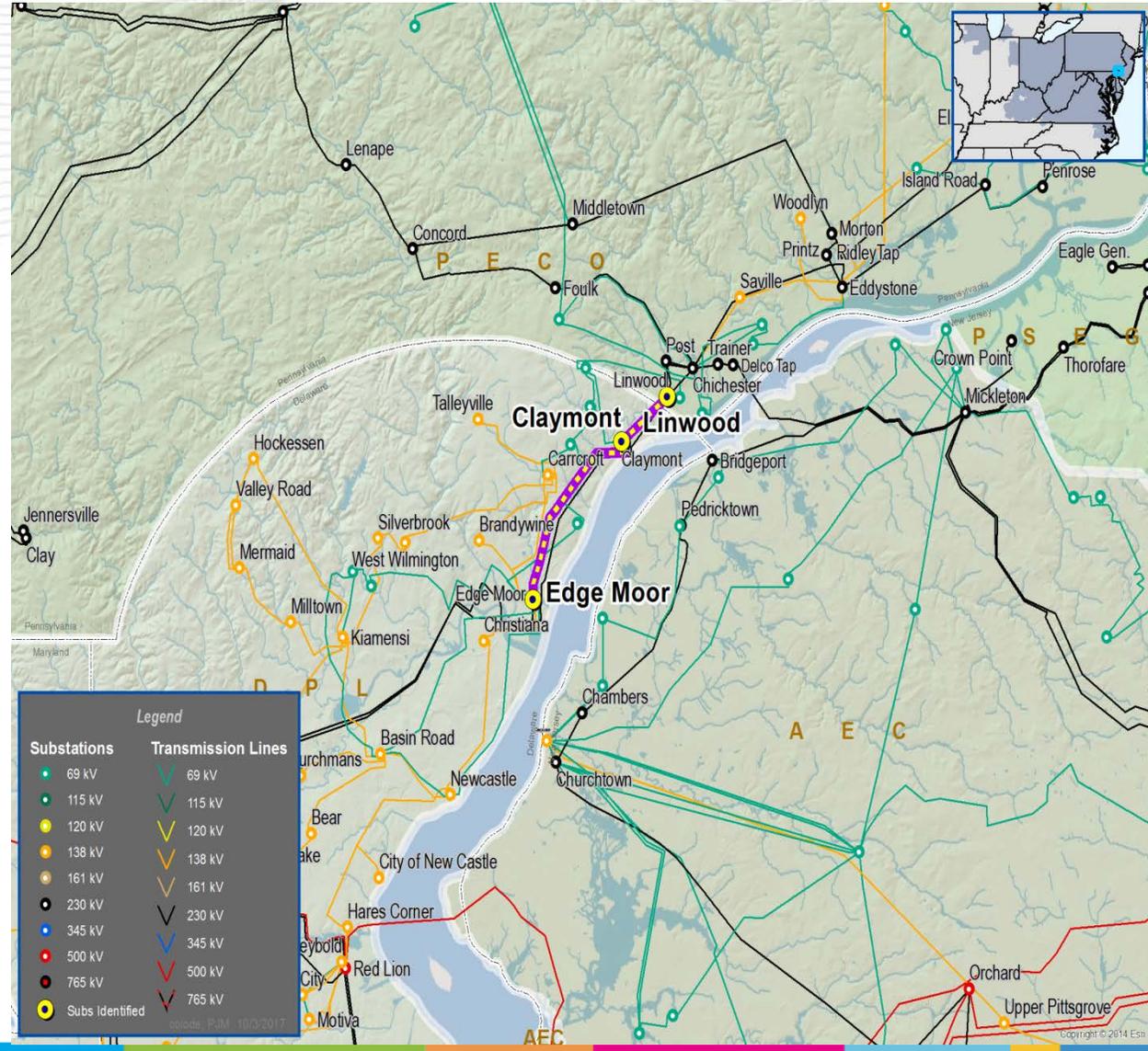
### Recommended Solution:

- Replace the 230 kV CB #225 at Linwood Substation (PECO) with a double circuit breaker (back to back circuit breakers in one device).  
2017\_1-9L

**Estimated Project Cost: \$ 1.4 M**

**Required IS date: 6/1/2022**

**Project Status: Conceptual**





# Operational Performance Project Update

**Baseline Reliability: Operational Performance**  
**Date Project Last Presented: 12/14/2017 TEAC**

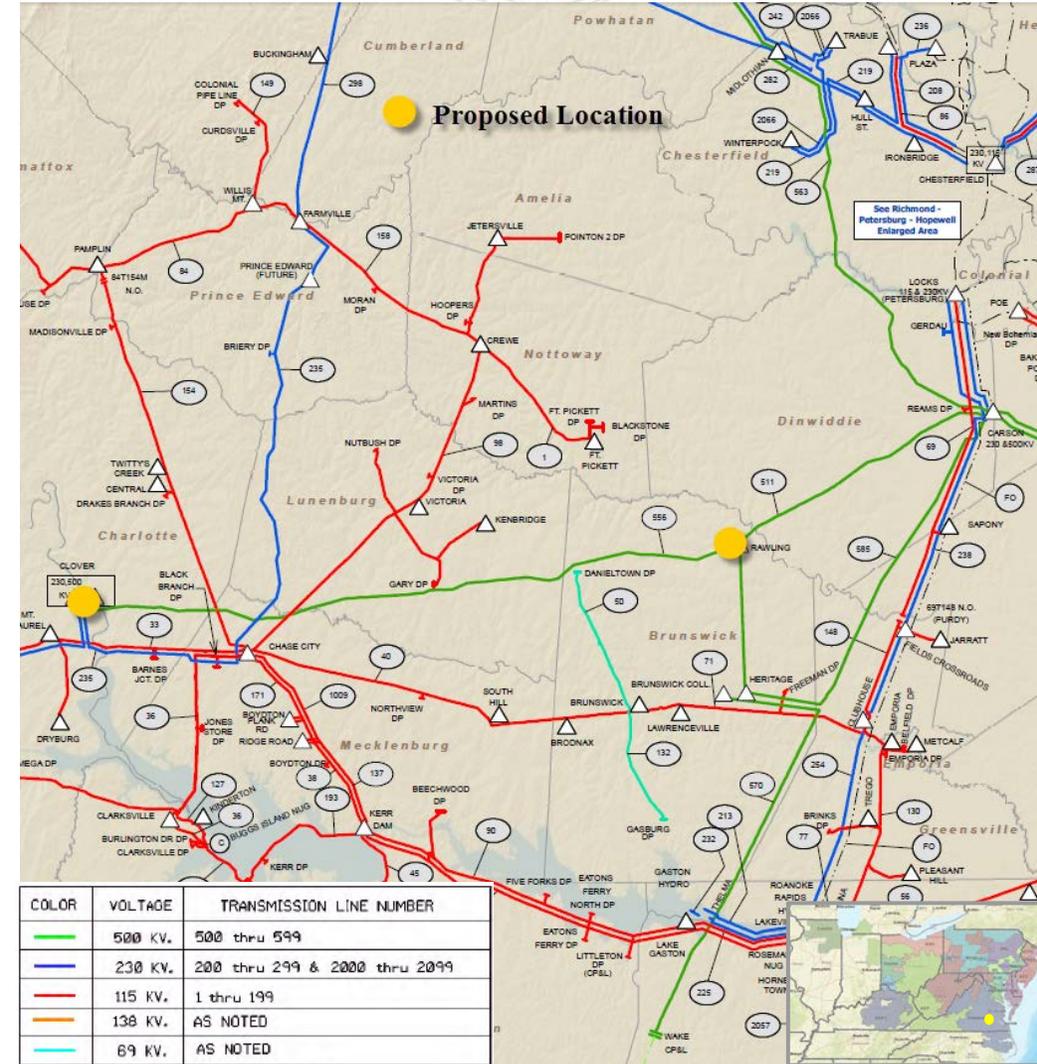
**Problem Statement:**

- PJM Operations continues to experience high voltage on the 500kV transmission system in the Carson area during periods of light system load.
- PJM Operations has implemented an operating memo to include switching out multiple 500kV transmission lines and scheduling necessary generation to run for high voltage control.

**Immediate Need:**

- Due to the immediate need, the timing required for an RTEP proposal window is infeasible. As a result, the local Transmission Owner will be the Designated Entity.

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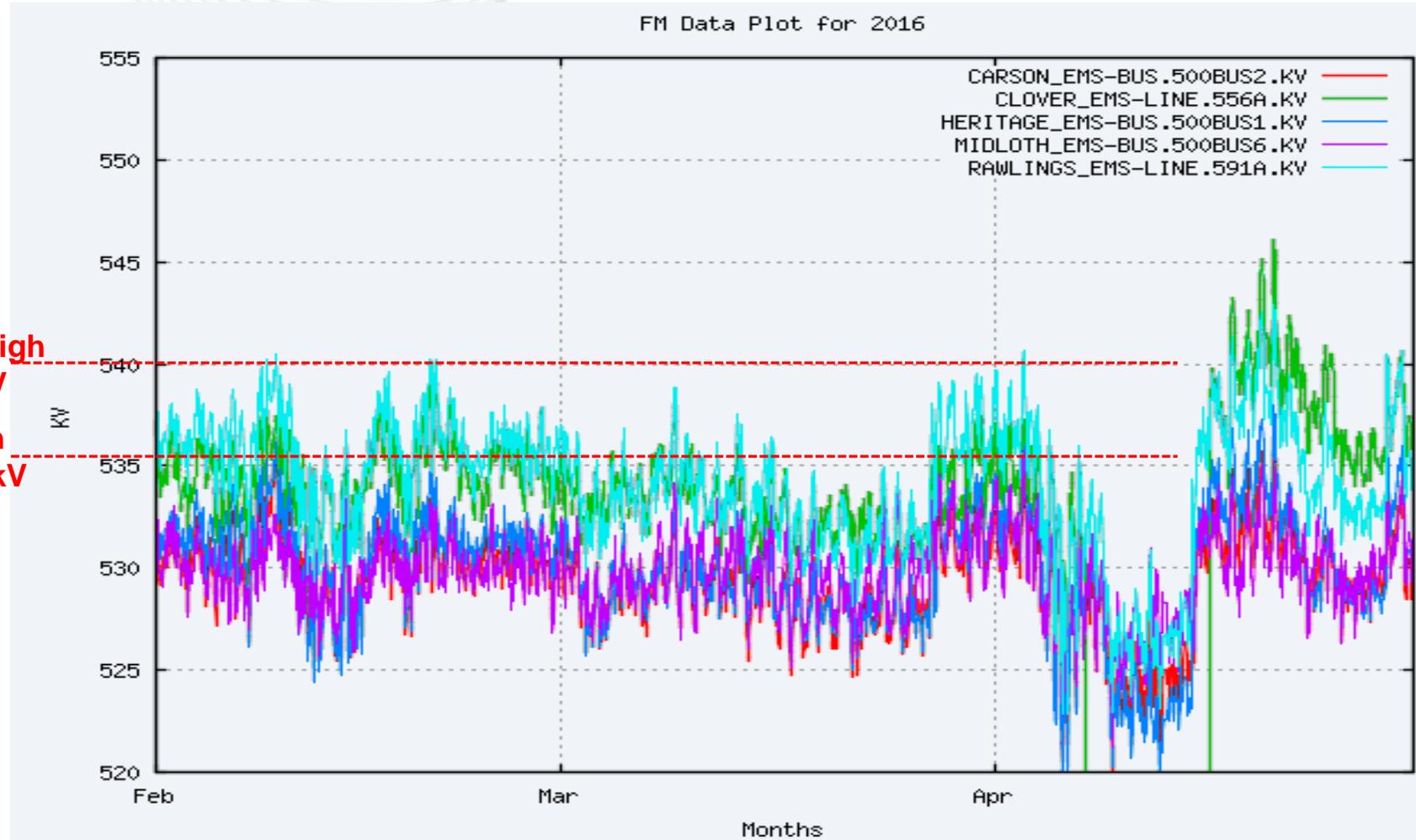
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Notes:

- Transmission line outages typically improve (by lowering) high system voltages

**Emergency High  
Limit 540.0 kV**

**Normal High  
Limit 535.5 kV**



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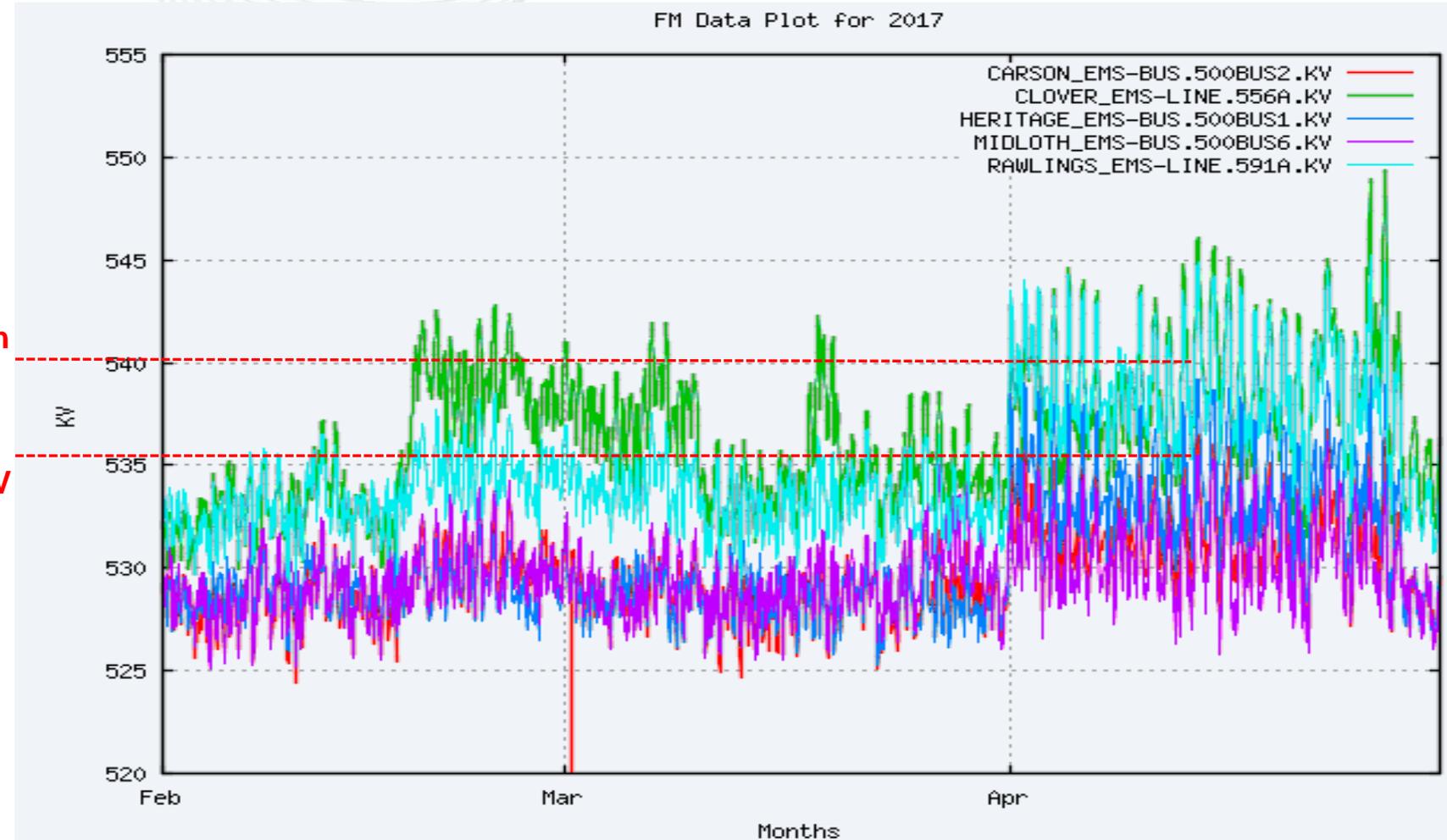
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## Notes:

- Generator outages in April (Brunswick County CC and Clover Unit #2)
- Transmission line outages typically improve (by lowering) high system voltages

**Emergency High  
Limit 540.0 kV**

**Normal High  
Limit 535.5 kV**



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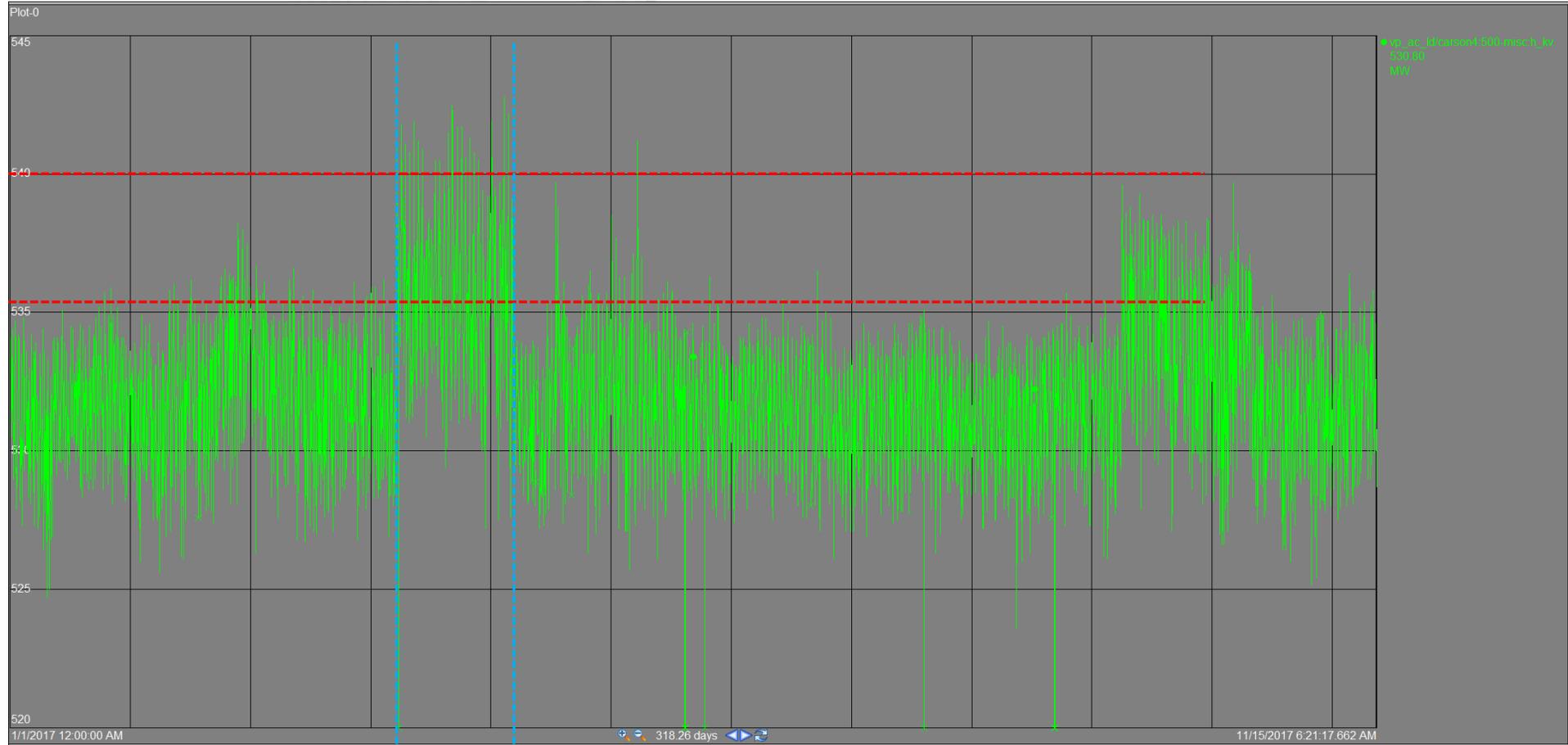
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**Emergency High  
Limit 540.0 kV**

**Normal High  
Limit 535.5 kV**

Notes:

- Generator outages in April (Brunswick County CC and Clover Unit #2)
- Transmission line outages typically improve (by lowering) high system voltages

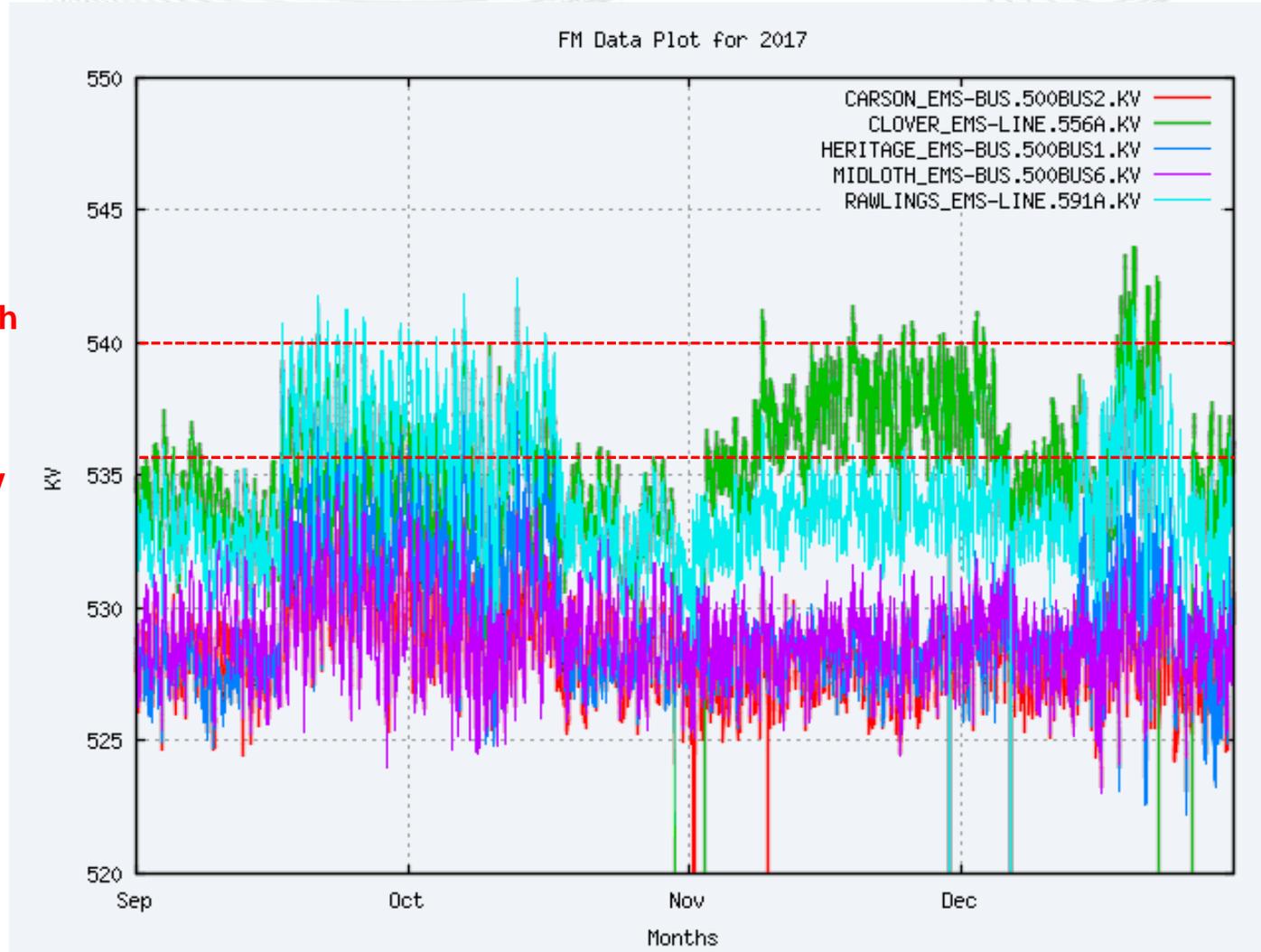


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**Emergency High  
Limit 540.0 kV**

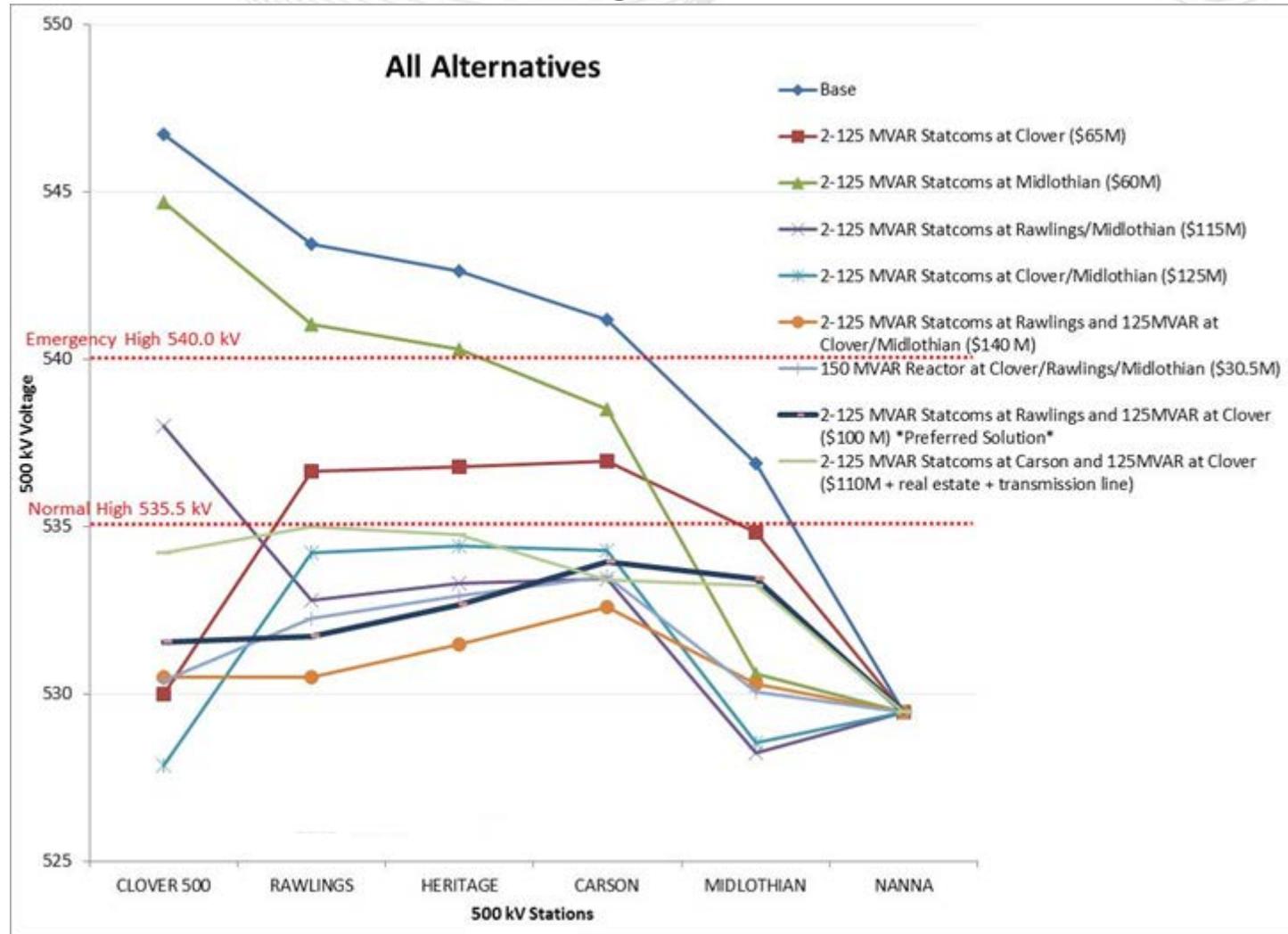
**Normal High  
Limit 535.5 kV**



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### EMS 02/24/2017 Snapshot 500kV Bus Voltages Before and After

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## Reactors

- Steady-state only
  - Must energize pre-contingency
- Significant operational and O&M issues with switching reactors (breakers and RL switchers)
  - Replacement of interrupter required on an annual basis
- No acceptable switching solution for 500kV

## STATCOMs

- 3-in-1 device (some modes can operate simultaneously):
  - Dynamic VAR support
  - Fixed reactor bank
  - Fixed capacitor bank
- Additional control functions beyond VAR support:
  - Phase balancing (reduce negative sequence)
  - Oscillation damping
  - Blackstart support

**Baseline Reliability:** Operational Performance  
**Date Project Last Presented:** 12/14/2017 TEAC

**Problem Statement:**

- PJM Operations continues to experience high voltage on the 500kV transmission system in the Carson area during periods of light system load.
- PJM Operations has implemented an operating memo to include switching out multiple 500kV transmission lines and scheduling necessary generation to run for high voltage control.

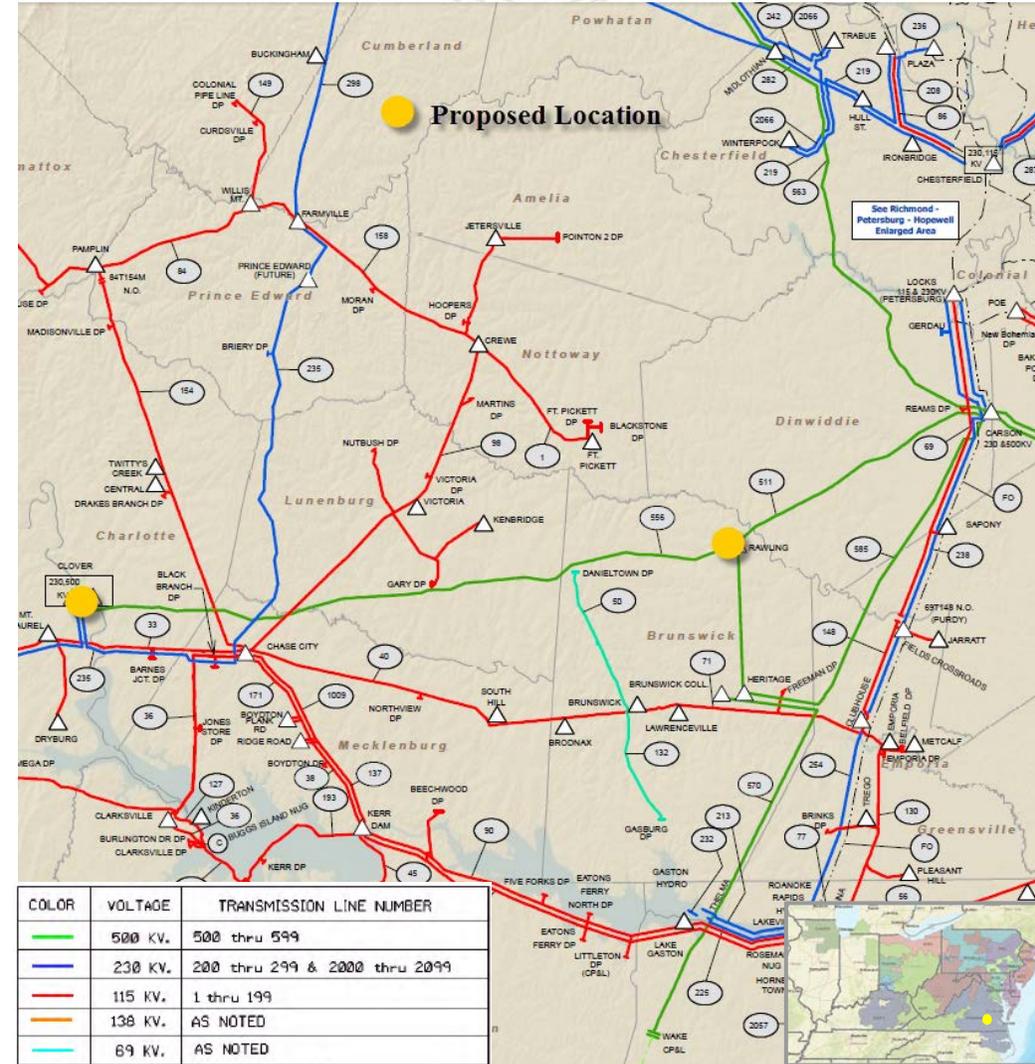
**Immediate Need:**

- Due to the immediate need, the timing required for an RTEP proposal window is infeasible. As a result, the local Transmission Owner will be the Designated Entity.

**Recommended Solution:**

- Install two 500kV 125 MVAR Statcoms at Rawlings and one 500kV 125 MVAR Statcom at Clover Substation. (\$100 M) (b2978)

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## Alternatives:

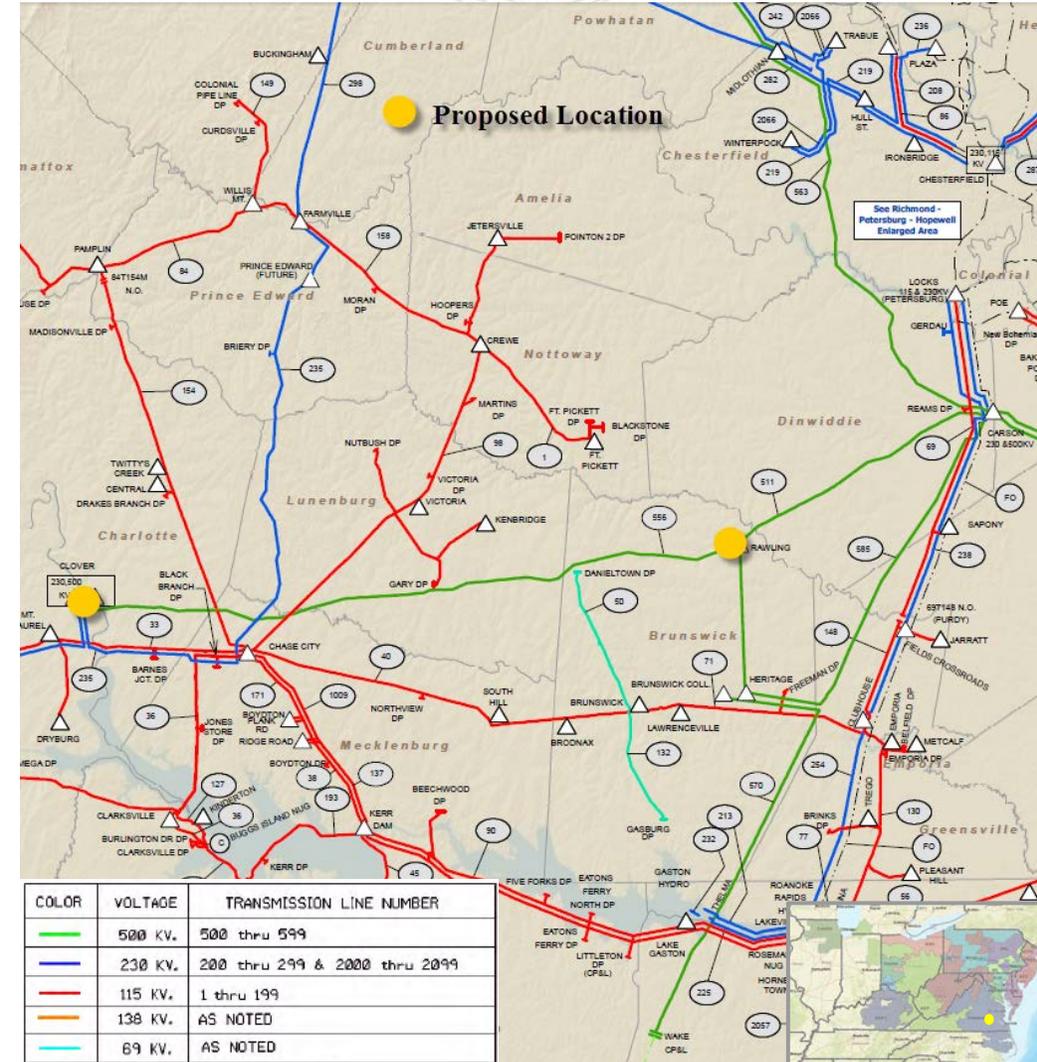
- Install two 500kV 125 MVAR Statcoms at Clover and at Midlothian Substation. (\$125 M)
- Install two 500kV 125 MVAR Statcoms at Carson and one 500kV 125 MVAR Statcom at Clover Substation. (\$110M + real estate + transmission line cost)
- Install two 500kV 125 MVAR Statcoms at Rawlings and one 500kV 125 MVAR Statcom at Midlothian and at Clover Substation. (\$140 M)
- Install one 500kV 150 MVAR Fixed Shunt Reactor bank at Rawlings Substation, at Clover Substation, and at Midlothian Substation. (\$30.5 M)
  - Current manufacturer designed duty cycle recommendation limits the 500kV reactor bank breaker switching operations to 250. This will require periodic replacement of interrupters and a two week outage.

**Estimated Project Cost: \$100 M**

**Required IS Date: Immediate**

**Projected IS Date: May 2021**

**Project Status: Conceptual**



# Dominion Update

## Project Estimated Cost Increases

## Existing b2745 Cost Increase

**Baseline Reliability:** 2016 RTEP Window #1 Generation Deliverability and Common Mode Outage ( FG# 60, 61, 62, 66, 68, 70, 71, 72, 76, 78, 248, 249) & DOM End of Life Facility

### Problem Statement:

- The Chesterfield – Messer Road – Charles City Road 230kV circuit is overloaded for several contingencies
- This facility is also a Dominion local transmission owner End of Life criterion violation in the near term planning horizon.

### Recommended Solution:

- Rebuild 21.32 miles of existing line #217 between Chesterfield and Lakeside 230 kV. (2016\_1-3B) (**b2745**)

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## Existing b2745 Cost Increase

### Reason for Cost Increase:

- Wetlands in and around the existing ROW creating challenging and costly access and clearing issues.
- Communication fiber relocation due to outage constraints on the existing fiber loop that were not known at the time of original estimate.
- Additional river structures identified for replacement due to condition of structures.

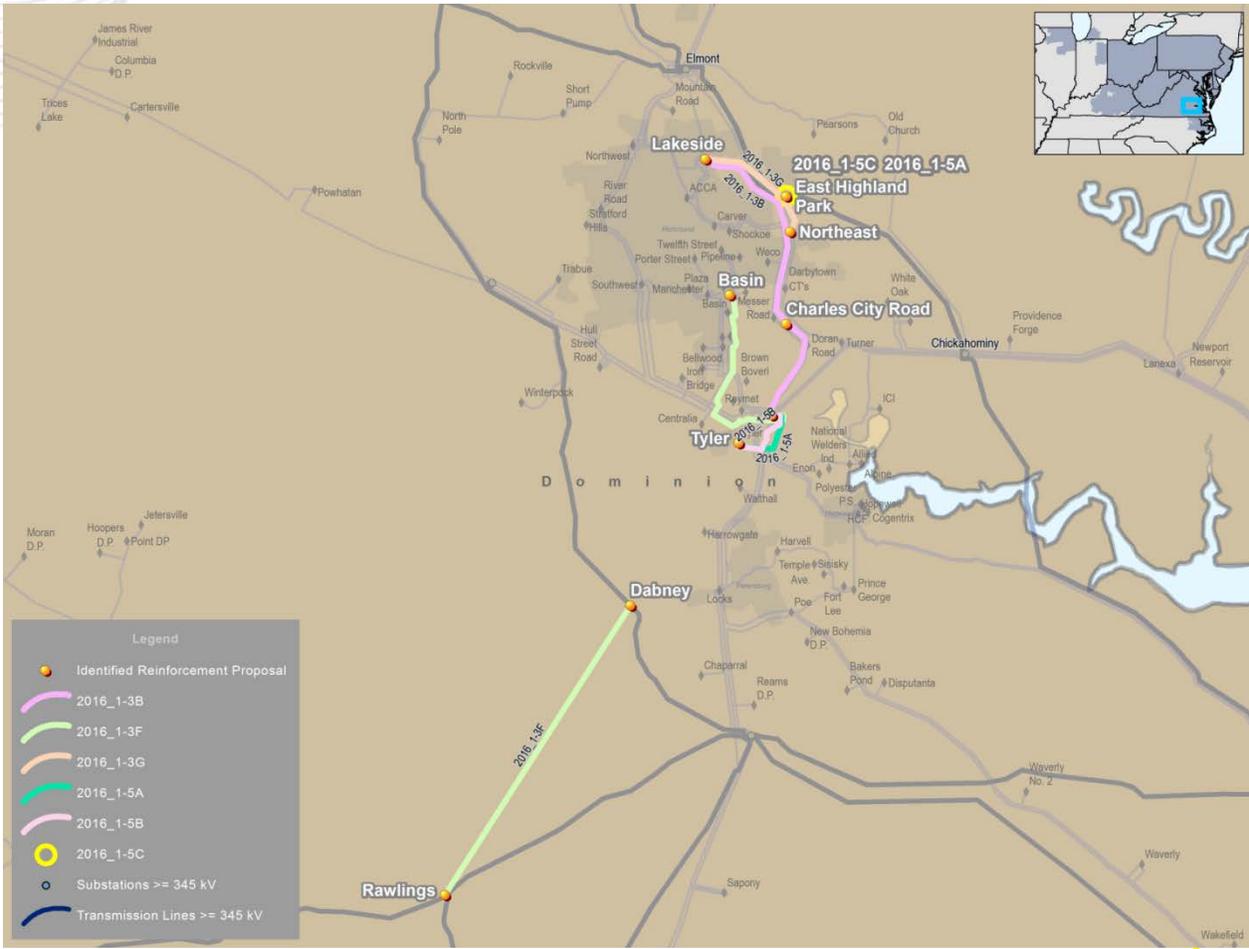
**Previous Estimated Project Cost: \$22.0 M**

**Revised Estimated Project Cost: \$31.7 M**

**Required IS Date: 6/1/2020**

**Project Status: Engineering**

**Previous TEAC Date: 5/12/2016**

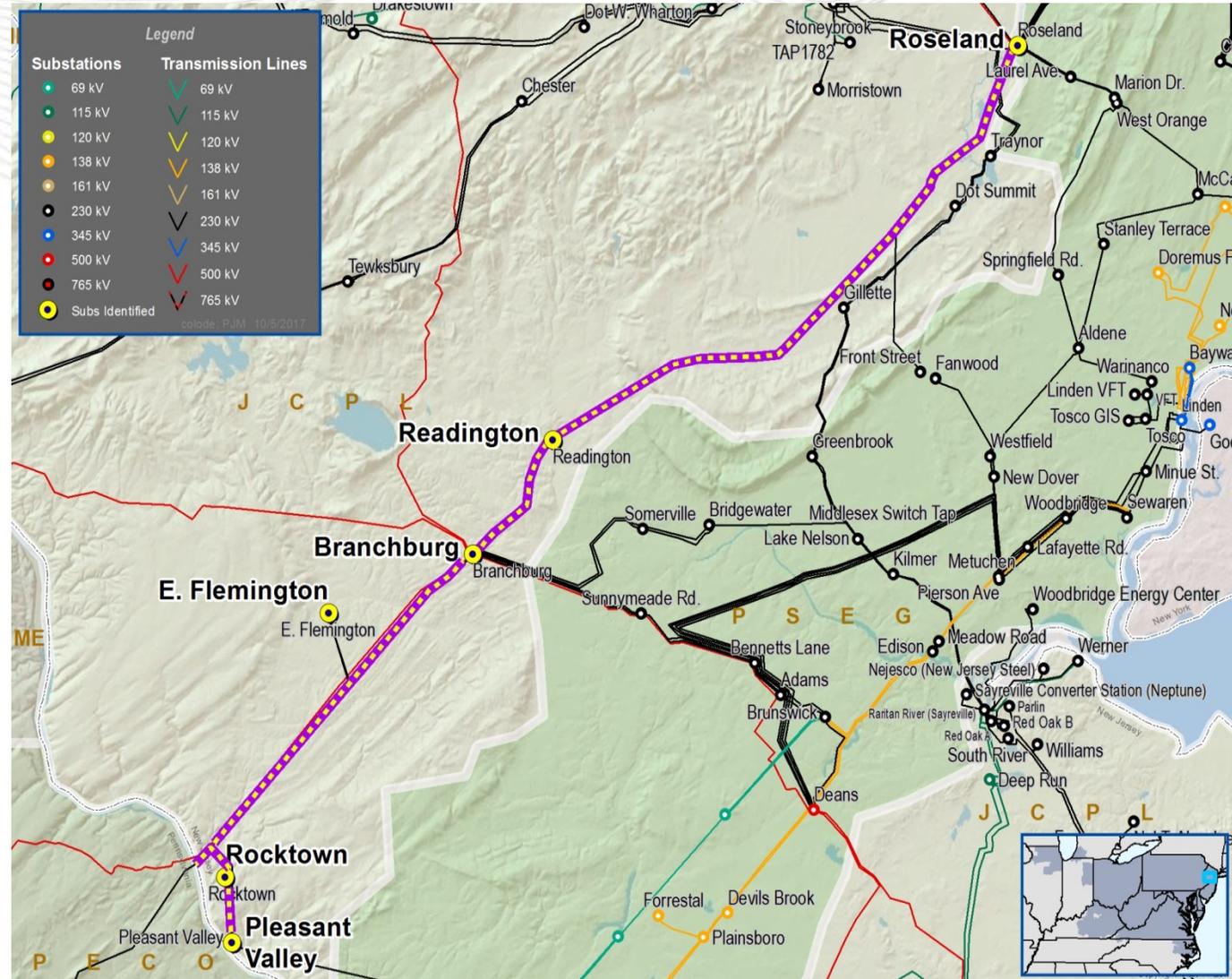


# TO Criteria Baseline Project Update

# PSE&G FERC 715 Local Criteria - Equipment Assessment

Roseland – Branchburg – Pleasant Valley  
Corridor

- PSE&G's FERC 715 Transmission Owner criterion addresses equipment condition assessments
  - PSE&G assessed the condition of the Roseland to Branchburg to Pleasant Valley 230 kV circuits.



- Refer to PSE&G criteria:

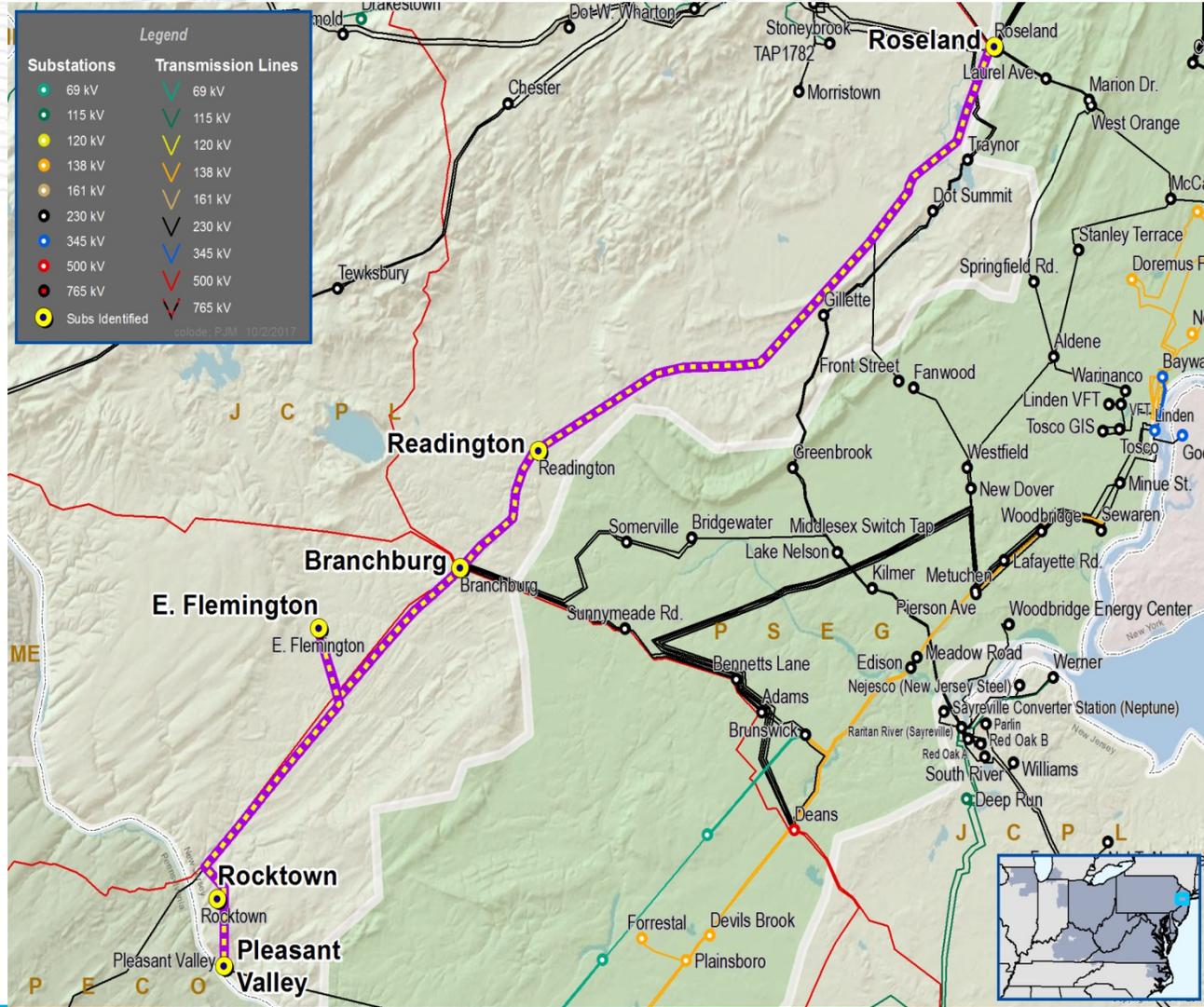
## VII. EQUIPMENT ASSESSMENT AND STORM HARDENING

<http://www.pjm.com/~media/planning/planning-criteria/PSE&G-planning-criteria.ashx>

- Roseland to Branchburg is approximately 30 miles of 230 kV circuit and the average structure age is approximately 90 years.
- Branchburg to Pleasant Valley is approximately 22 miles of 230 kV circuit and the average structure age is approximately 90 years.
- Parallel to Roseland-Branchburg 500kV corridor
- The terrain is variable and includes rural, National Wildlife Refuge and municipalities
- This facility also serves 240 MVA sub-transmission load in adjacent territory (JCP&L)

- PSE&G commissioned external consultants to assess tower foundations and tower structures of the 50 mile Pleasant Valley-Branchburg-Roseland corridor
  - Assessment result:
    - The assessments identified towers with foundations needing reconstruction, towers exceeding loading capability, Also identified through LiDAR are NESC ground conflicts; the Project was developed as a result.
- These towers were built in 1927-1930. Small portions were rebuilt from 1961 to 2015 (see next slide). At 795 ACSR, some existing conductors are smaller than the current standard of 1590 ACSR.
- The two major components of the overall corridor are the Roseland – Branchburg segment and the Branchburg – Pleasant Valley segment

- **Assessment Result:**
  - Consultant findings – Transmission Tower Foundation assessment
    - About 25% of structures for Roseland – Branchburg – Pleasant Valley will require either extensive foundation rehabilitation or total foundation replacement.
  - Consultant findings – Tower line assessment
    - Due to the present condition, 54% of the towers are exceeding 100% of the tower’s load bearing capability, and 84% of the towers are exceeding 95% of the tower’s capability.
    - 9% of spans violate LiDAR ground conflicts



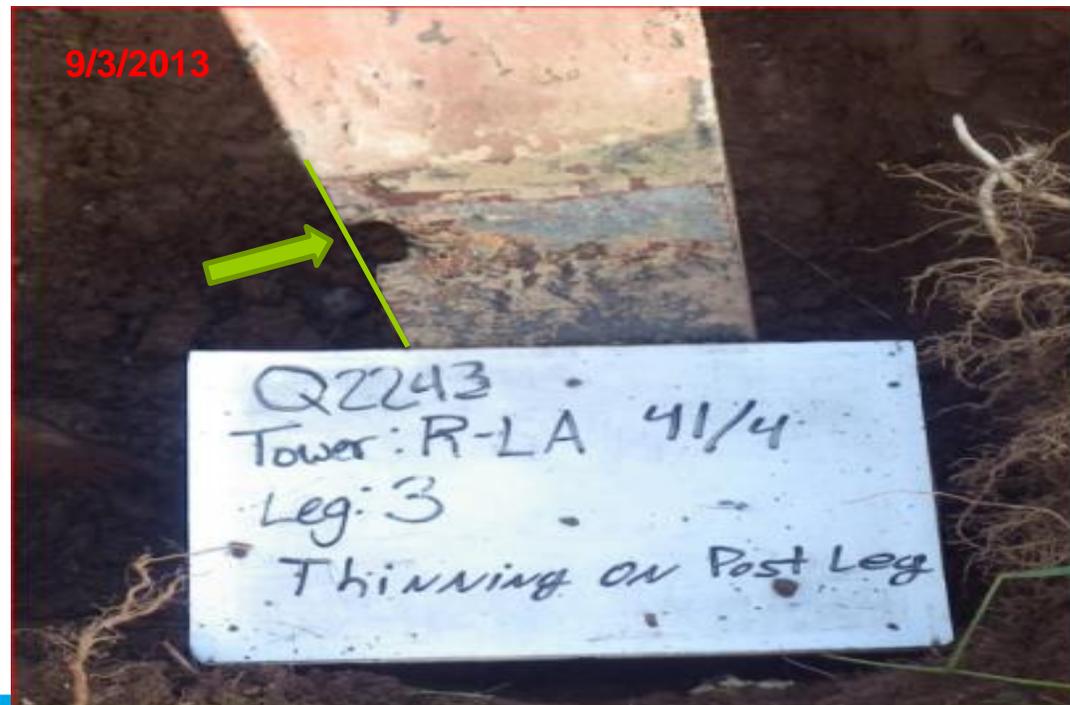
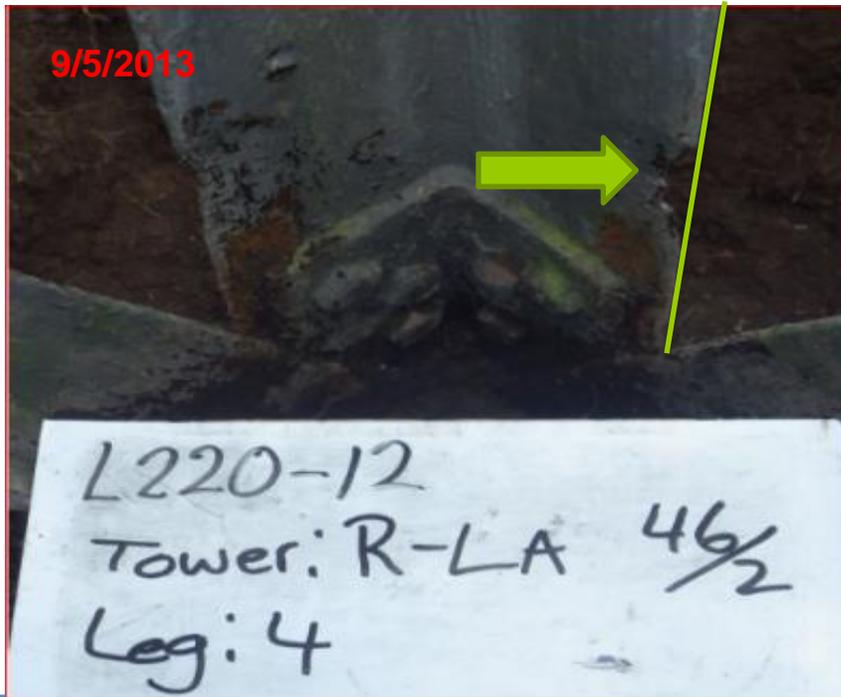
Tower Condition on Circuits U-2221, M-2265 (162 towers)	
Towers with foundation requiring extensive reconstruction	40 (25%)
Towers exceeding 95% loading capability	144 (89%)
Towers exceeding 100% loading capability	129 (80%)
LIDAR conflict (# spans)	17* (10%)

\*LiDAR conflicts as of 9/29/2017



Evaluate Towers on Circuits I-2209, Q-2243, Z-2357, L-220-12 (102 towers)	
Towers with foundation requiring extensive reconstruction	27 (26%)
Towers exceeding 95% loading capability	77 (76%)
Towers exceeding 100% loading capability	14 (14%)
LIDAR conflicts (# spans)	7* (7%)

\*LiDAR conflicts as of 9/29/2017



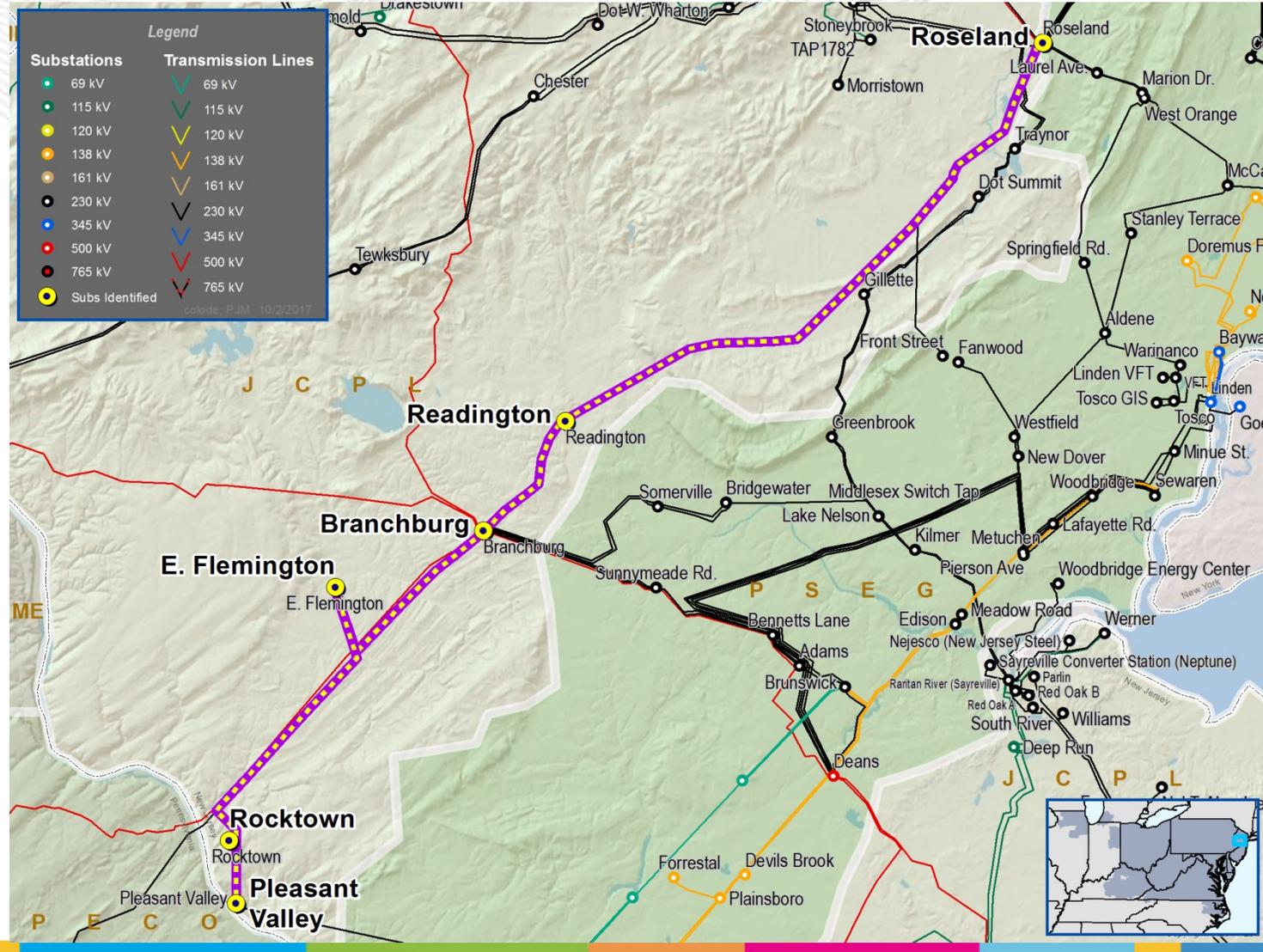


# PSE&G Transmission Zone Roseland – Branchburg – Pleasant Valley Corridor

## Problem:

## PSE&G FERC 715 local Transmission Owner Criteria

- Equipment condition assessment for the entire corridor
- Equipment has reached its end of life



1. Remove and retire the 230 kV corridor without replacing
2. Install new parallel circuit on new right-of-way and remove existing 230 kV corridor
3. Replace the existing 230 kV single-circuit corridor with new dual-circuit structures and initially string one 230 kV circuit

Remove the existing 230 kV corridor without replacing

- Would leave 240 MVA of JCP&L load supplied by 34.5kV sub-transmission with significant voltage and thermal violations
- Would require extensive construction, and associated cost, to relieve voltage and thermal violations on 34.5kV
- Loss of up to 996 MVA transmission system capacity
- Thermal/Voltage violations on the neighboring JCP&L system
- *Because of the above issues, removal without replacement is not a viable option.*

## Solution Alternative #2: Install New Circuit and Remove Existing

- Potential permitting challenges due to new facility
- Martinsville, East Flemington, Readington and Rocktown require feeds from 230/34.5kV substations and associated additional lines to loop in an out of each station
- Would require more than 50 miles of new overhead construction, new ROW and new permitting
- *Due to the above issues, installing new equipment in new areas is the highest cost option*

### Replace the existing 230 kV corridor with new structures

- Maintain system reliability
- Eliminate safety risk from damaged structures
- No new ROW required
- No new substations or reactive devices required
- No topology change – additional studies, extensive protection coordination not needed
- Minimal new siting, permitting and construction involved
- Maintain transmission capacity between Branchburg and Lawrence substations

## **Recommended solution:**

- Replace the existing Roseland – Branchburg – Pleasant Valley 230 kV corridor with new structures.

**Estimated Project Cost:** \$ 546 M

**Required IS date:** 2018

**Projected IS date:** 6/1/2022

**Project status:** Engineering

Note: PJM is continuing evaluation of this FERC 715 violation.

# Supplemental Projects

**Problem Statement:**

Equipment Material/Condition/Performance/Risk:

CB's J2, K2, L1, and JM at Twin Branch are all PK-type air blast breakers installed in the late 60's or early 70's. These four breakers are showing significant signs of deterioration. Drivers include age, number of fault operations, and a lack of available repair parts.

Breakers J2, JM and L1 are PK 3000A 41kA models. Breaker K2 is a PK 3000A 50kA model.

**Potential Solution:**

Remove and replace 345kV circuit breakers L1, K2, JM and J2 with 5000A 63kA models.

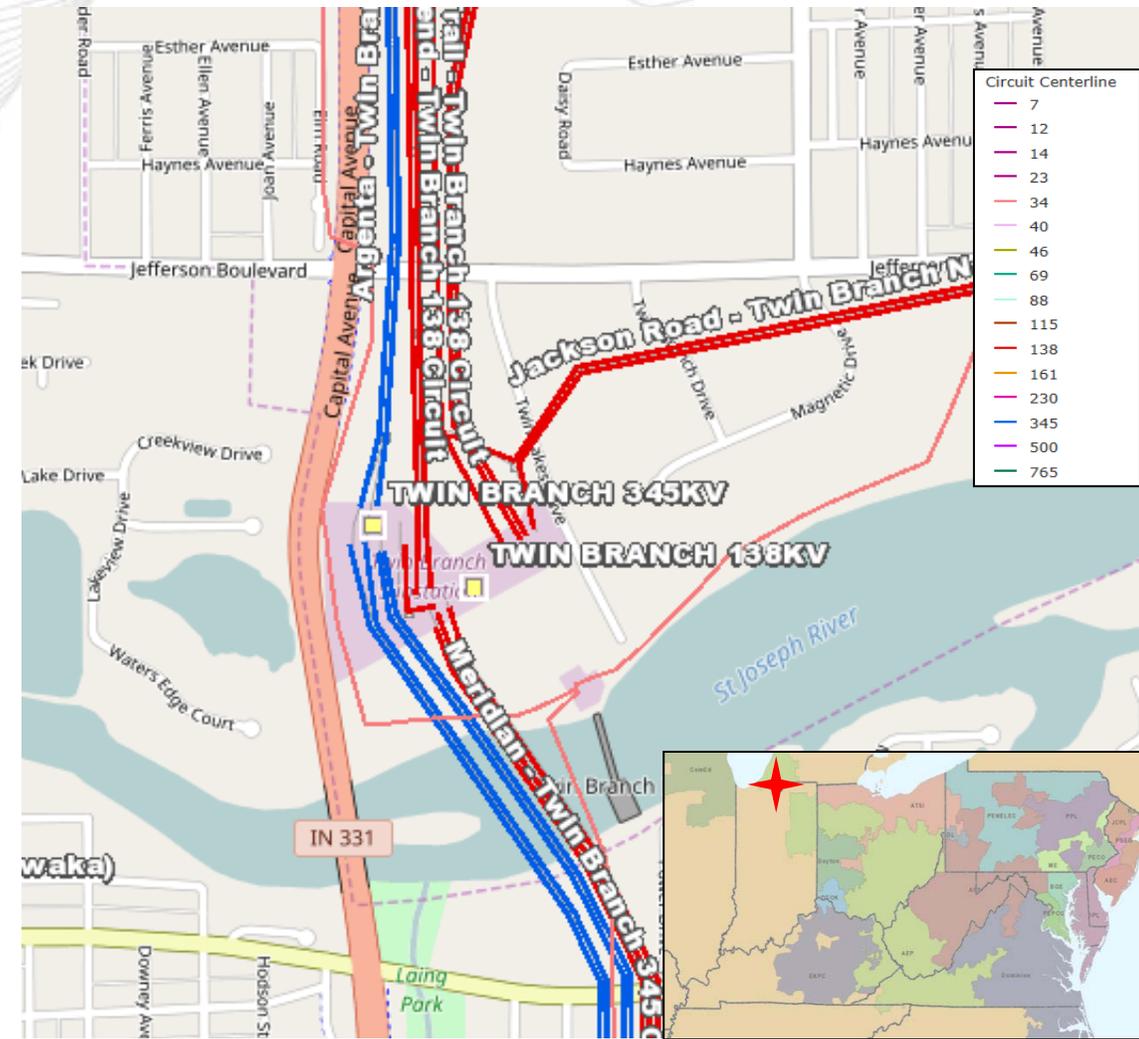
**Estimated Transmission Cost: \$8.4 M**

**Alternatives:**

No viable cost effective alternates were identified

**Projected In-service: 12/31/2018**

**Project Status: Engineering**



# Supplemental Projects – Previously Reviewed

## Supplemental Project

Previously presented: 12/14/2017

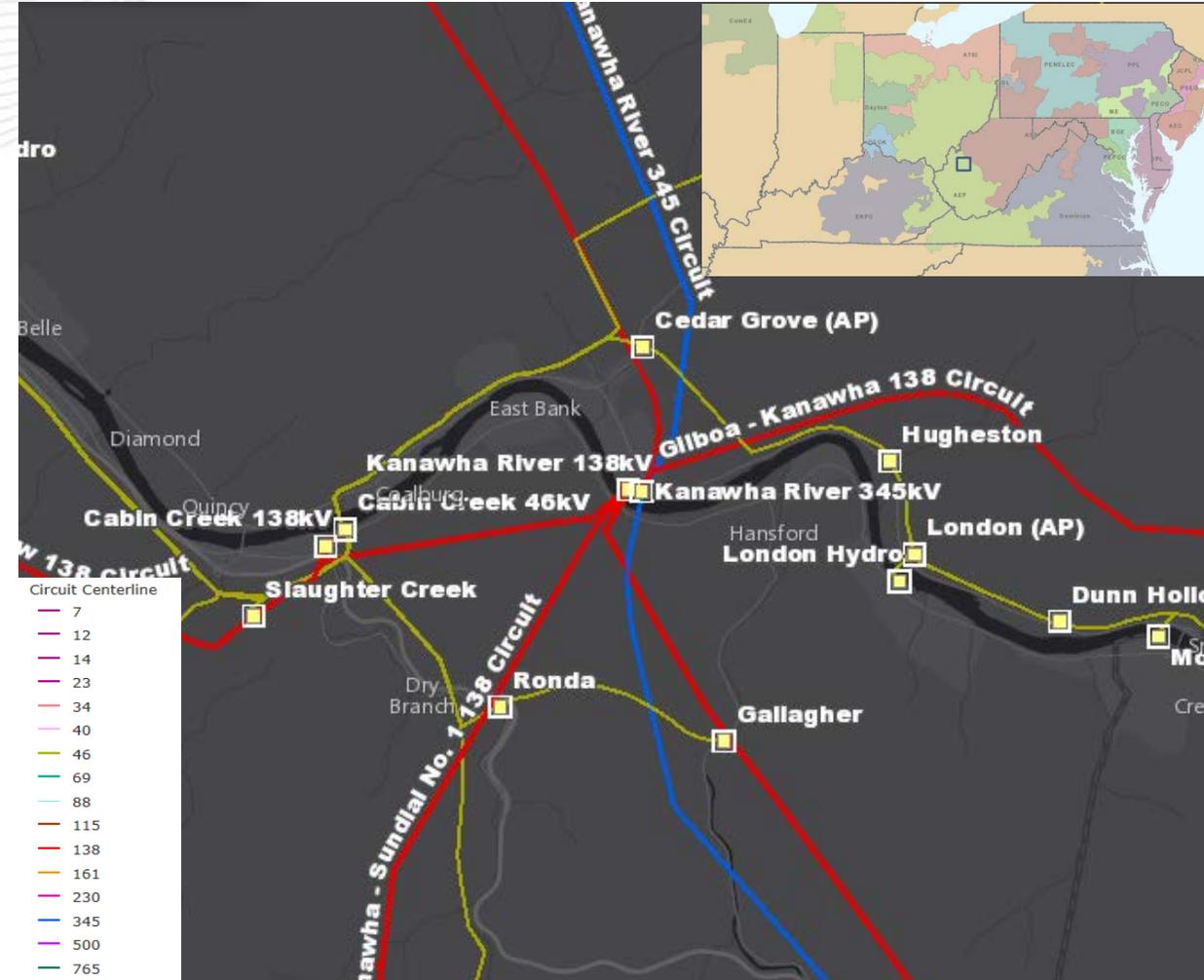
### Problem Statement:

#### Equipment Material/Condition/Performance/Risk:

345 kV circuit breakers "Q", "Q1", and "Q2" are in poor condition due to corrosion issues and need replacement (vintage 1988). All three breakers are SF6, FX-22A type breakers which is an obsolete 345 kV model. AEP only has 8 of this type of breaker across the entire system and spare parts are difficult to come by. Additionally, the three subject breakers have significantly exceeded the designed number of 10 fault operations. Breaker Q has experienced 87 fault operations, Q1 has experienced 29 fault operations and Q2 has experienced 113 fault operations. All three breakers have also shown issues with their arcing contacts. Due to contact wear, not replacing the breakers can lead to catastrophic failure.

Kanawha River 345/138 "B" Bank will be replaced due to multiple issues and a high risk of failure (vintage 1973). Failure of this transformer could cause damage to other equipment at the station an oil leakage in the yard. Transformer B has experienced short circuit breakdown caused by the large amount of significant through fault events in excess of 700°C, increased and upward trending of gassing, major periods of overheating, and high concentration of combustible gases (acetylene, ethylene, ethane, and methane). Moreover, studies identified in the AEP Transmission Operations Seasonal Performance Appraisal for the 2017 Winter season show that the failure of 345/138 kV Transformer B would create an overload scenario on 345/138 kV Transformer A for the loss of the Kanawha River-Matt Funk 345 kV circuit. The reliability of each transformer is critical if the other transformer is removed from service.

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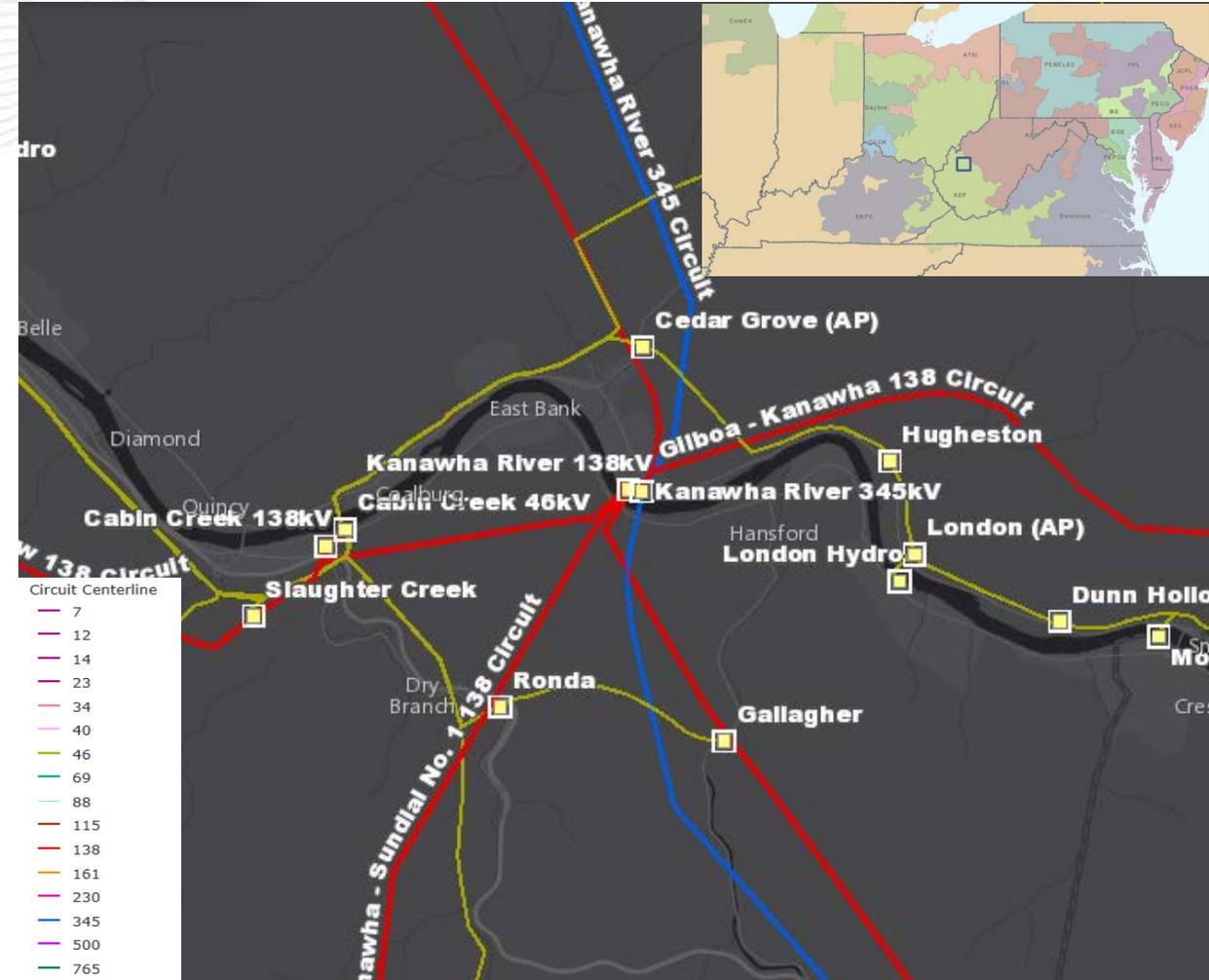
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The Kanawha River 345 kV Series Capacitor was installed on the APCo transmission system in 1991 to improve loadability of the Kanawha-Matt Funk 345 kV 108 mile line by reducing its apparent impedance. The existing series capacitor consists of three impedance compensation (i.e. reduction) segments. Segment 1 (10%), Segment 2 (20%), and Segment 3 (30%). Segments 1 and 2 are located on one platform while the segment 3 on a separate platform. The fiber optic cable used in Segment 1 is in complete failure. The power supply for Segment 2 has failed. The control cards for both Segment 1 and Segment 2 have been used to keep Segment 3 available. Segments 1 and 2 cannot be repaired due to lack of parts and Segment 3 may not operate when called upon due to inadequate protection and control equipment. The fiber optic cable in Segment 3 is also on the verge of failure based on recent testing. Due to its age, spare parts are unavailable because they are no longer produced by the manufacturer. The lifecycle of a capacitor in a substation environment is 30 years, and these capacitors are approaching their end of life. In addition, upgrading the protection and control equipment is not an option due to the fact that modern relaying packages are not compatible with the aged series capacitor.

### Operational Flexibility and Efficiency

The 345 kV series capacitor is used to help maintain the reliability on the transmission grid and allows flexibility during maintenance and construction outages. Reliability is maintained by adhering to voltage and thermal limits to withstand additional system disturbances. Specifically, the 345 kV Series Capacitor Bank is needed to alleviate Interconnection Reliability Operating Limit (IROL) constraints.

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The 345 kV Series Capacitor Bank is used during heavy power flow winter conditions and/or during a significant outage to alleviate voltage and thermal constraints. Since 2014, the series capacitor was used five times to help alleviate operational concerns. The 345 kV Series Capacitor Bank can provide voltage support to the 138 kV system during heavy transfers to the Dominion interface under multiple outage conditions.

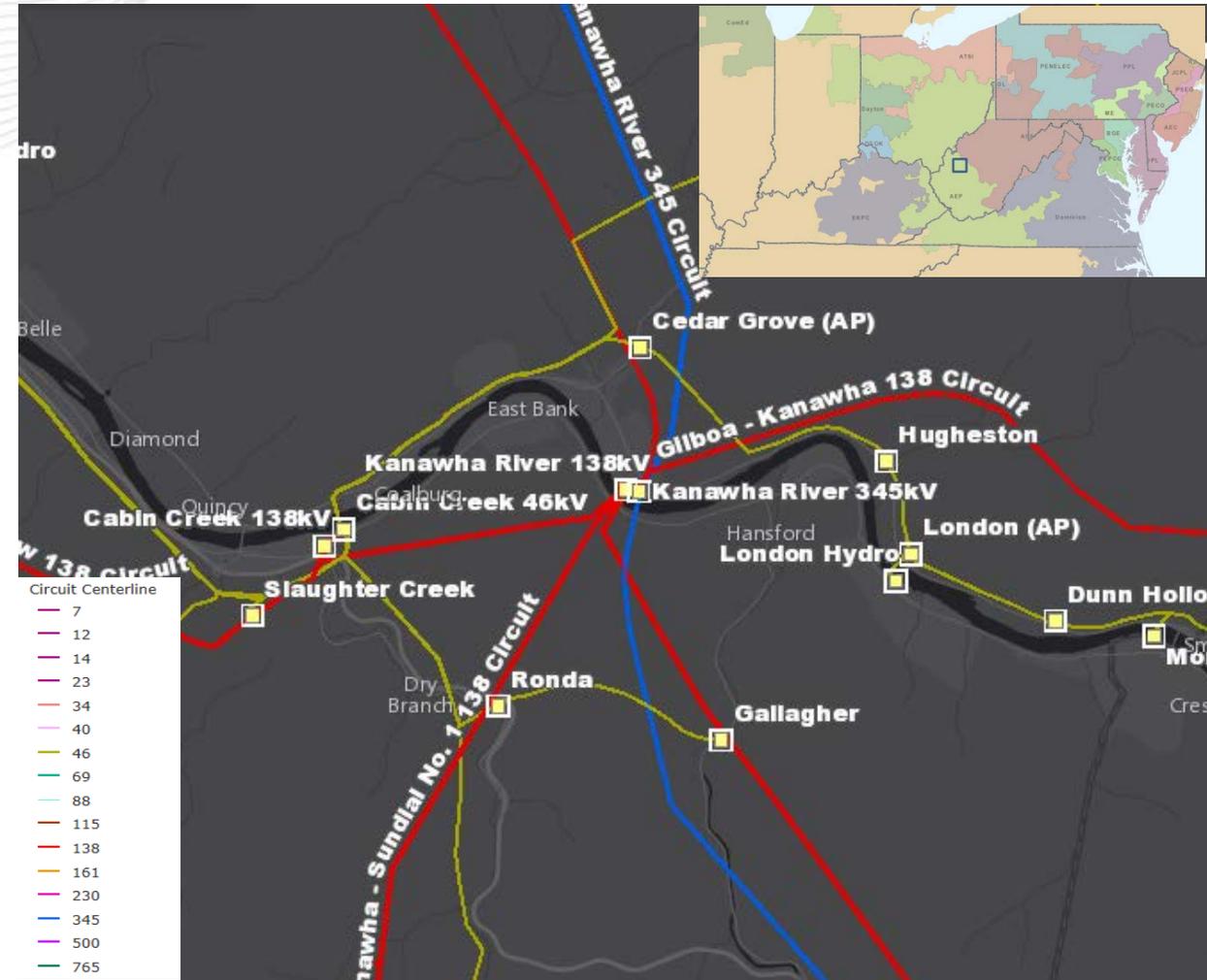
**Selected Solution:**

Replace three existing 3000 A 50 kA 345 kV circuit breakers Q, Q1 and Q2 with new 5000 A 63 kA circuit breakers. Replace the three sections of the existing Kanawha River Series Capacitor with a single 24 ohm 3000 A series capacitor. Replace existing 400 MVA 345/138/13.8 kV XF with a new 450 MVA 345/138/13.8 kV XF. (S1461)

Total Estimated Transmission Cost: \$30.0 M

Projected In-service: 12/12/2019

Project Status: Scoping



## Supplemental Project

Previously presented: 12/14/2017

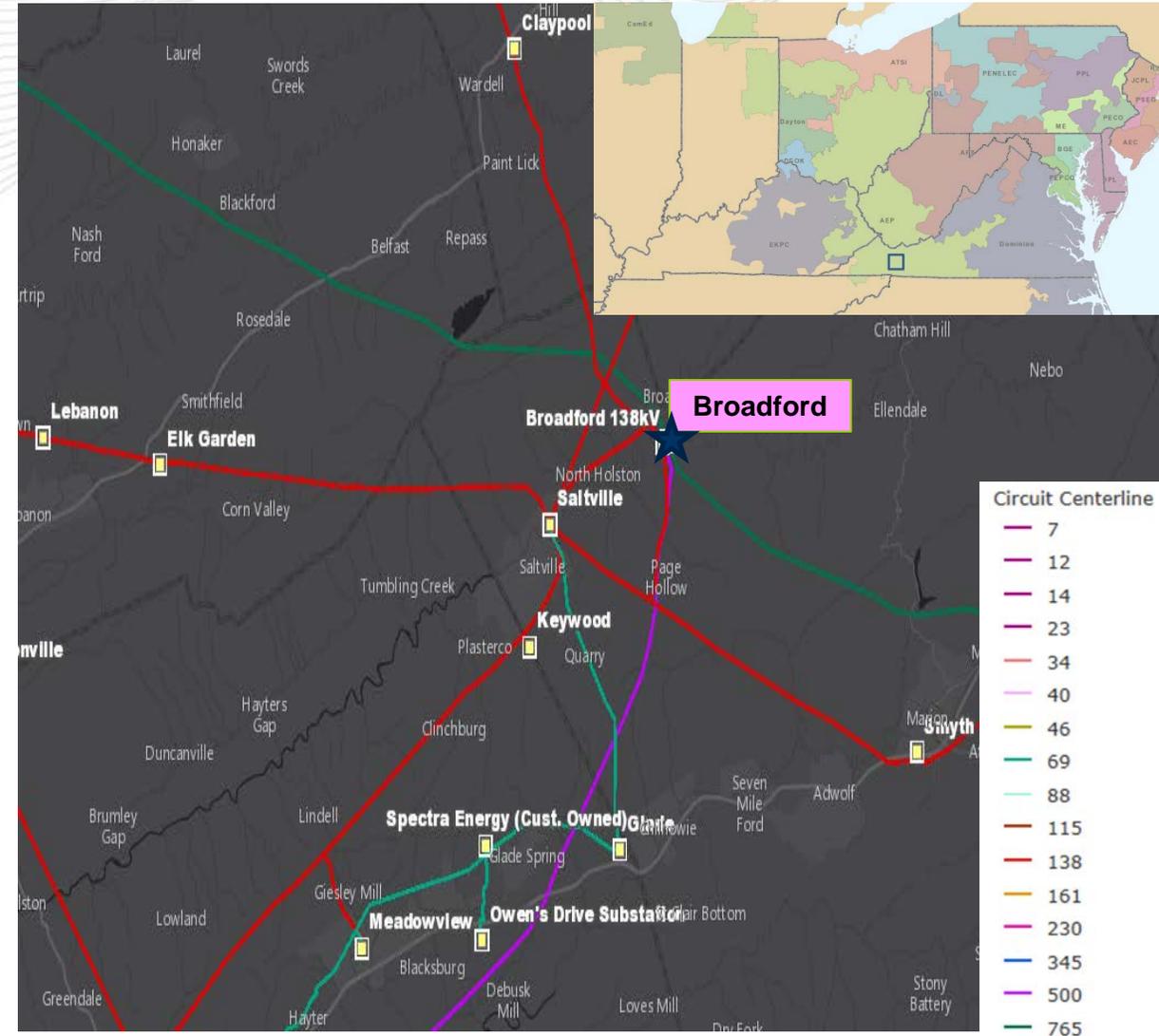
### Problem Statement:

#### Equipment Material/Condition/Performance/Risk/Operational Flexibility:

138kV breakers B, B1, B2, C, and C1 are all air blast breakers type PK-2B40 and 2B50. Air blast breakers are being replaced across the AEP system due to reliability concerns, intensive maintenance, and tendency to fail, catastrophically. During failures, sharp pieces of porcelain from bushings are expelled, which are a potential safety hazard to field personnel. In addition, manufacturers do not develop spare for these types of breakers. The Manufacturers' recommended number of fault operations is 10. Breaker B has experienced 47 fault operations, breaker B1 has experienced 127 fault operations, breaker B2 has experienced 102 fault operations, breaker C has experienced 63 fault operations, and breaker C1 has experienced 100 fault operations .

Drivers for 765/138 kV 600 MVA transformer # 1 (vintage 1969) include bushing damage and wear, dielectric strength breakdown (insulation breakdown), and short circuit strength breakdown due to through fault events. Additionally, transformer # 1 has high levels of Acetylene. Gas formations within a transformer are caused by electrical disturbances and/or thermal decomposition as a result of multiple thermal and/or electrical faults suffered through the life of the transformer.

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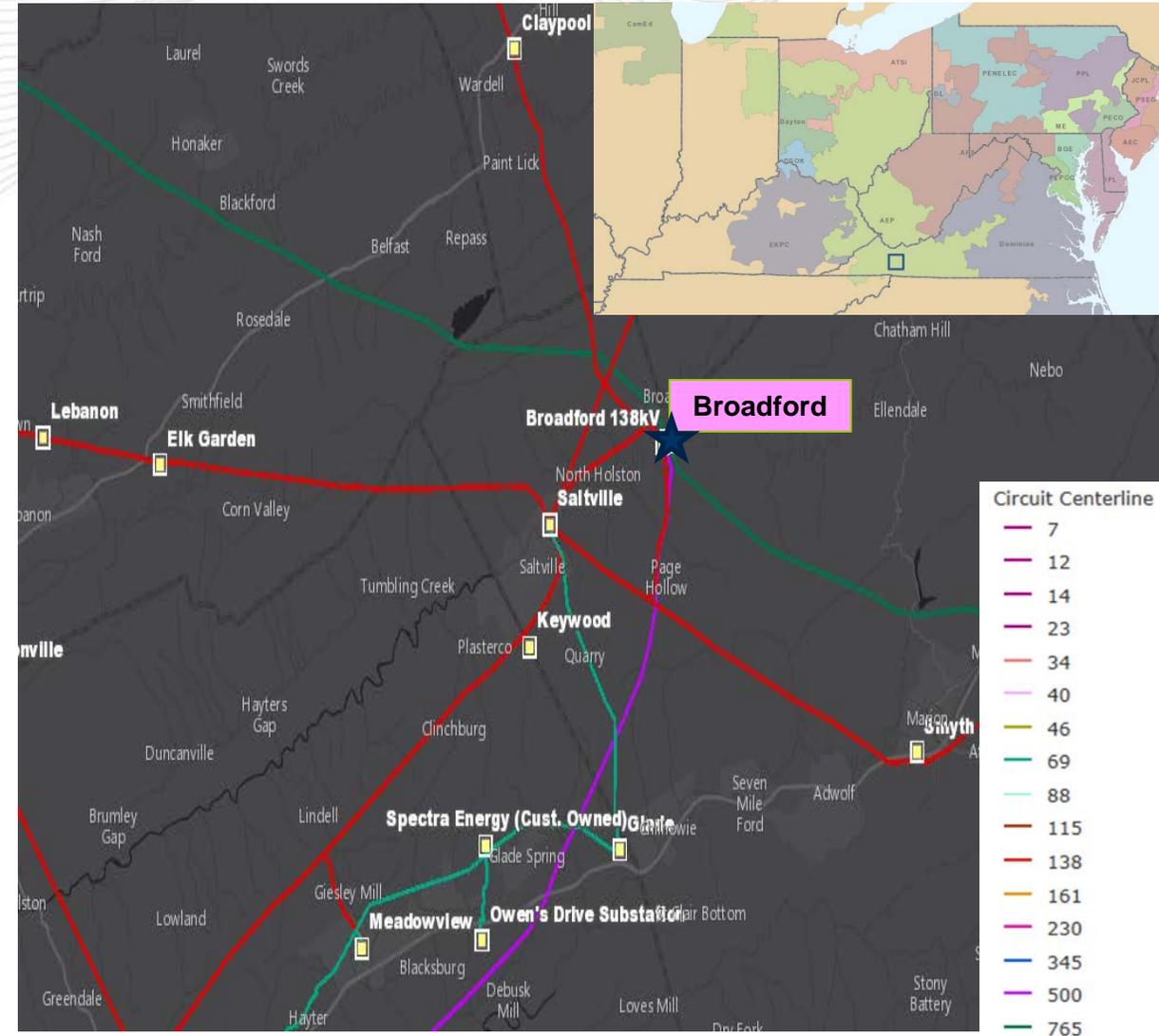
Drivers for 765/500 kV 1500 MVA transformer # 4 (vintage 1969) include short circuit strength breakdown (due to through fault events), dielectric strength breakdown (insulation), and bushing wear. Additionally transformer # 4 also has high Ethane and Carbon Dioxide levels dissolved in the oil.

**Operational Flexibility and Efficiency:**

Due to the lengthy outages and space constraints within the existing 765 kV yard, both 765 kV transformer replacements will need to be done in the clear. To accommodate the new transformers position, circuit breakers N, N1, and P will be installed. Taking transformers #1 and #4 off the bus will allow us to separate dissimilar zones of protection, which can lead to relay misoperations. In addition, due to space constraints and construction requirements, the new transformers cannot be physically placed back in their original locations.

Currently at the 138 kV yard, both the Broadford – Wolf Hills and Broadford – Atkins circuits are terminated directly on the bus. This creates dissimilar zones of protection (line and bus) that can cause misoperations. Broadford – Wolf Hills is approximately 30 miles long and Broadford – Atkins is approximately 20 miles long; terminating both of these lines into a new breaker string will help reduce the exposure on each circuit. Installing circuit breakers D, D1, and D2 will mitigate this relay protection issue along with subjecting equipment to undue fault conditions. The station will be reconfigured and the work will be done in the clear to lessen the impact of the outages that need to be taken. In doing so, the reactor and circuit breaker C2 will be replaced as part of the station reconfiguration.

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**Selected Solution:**

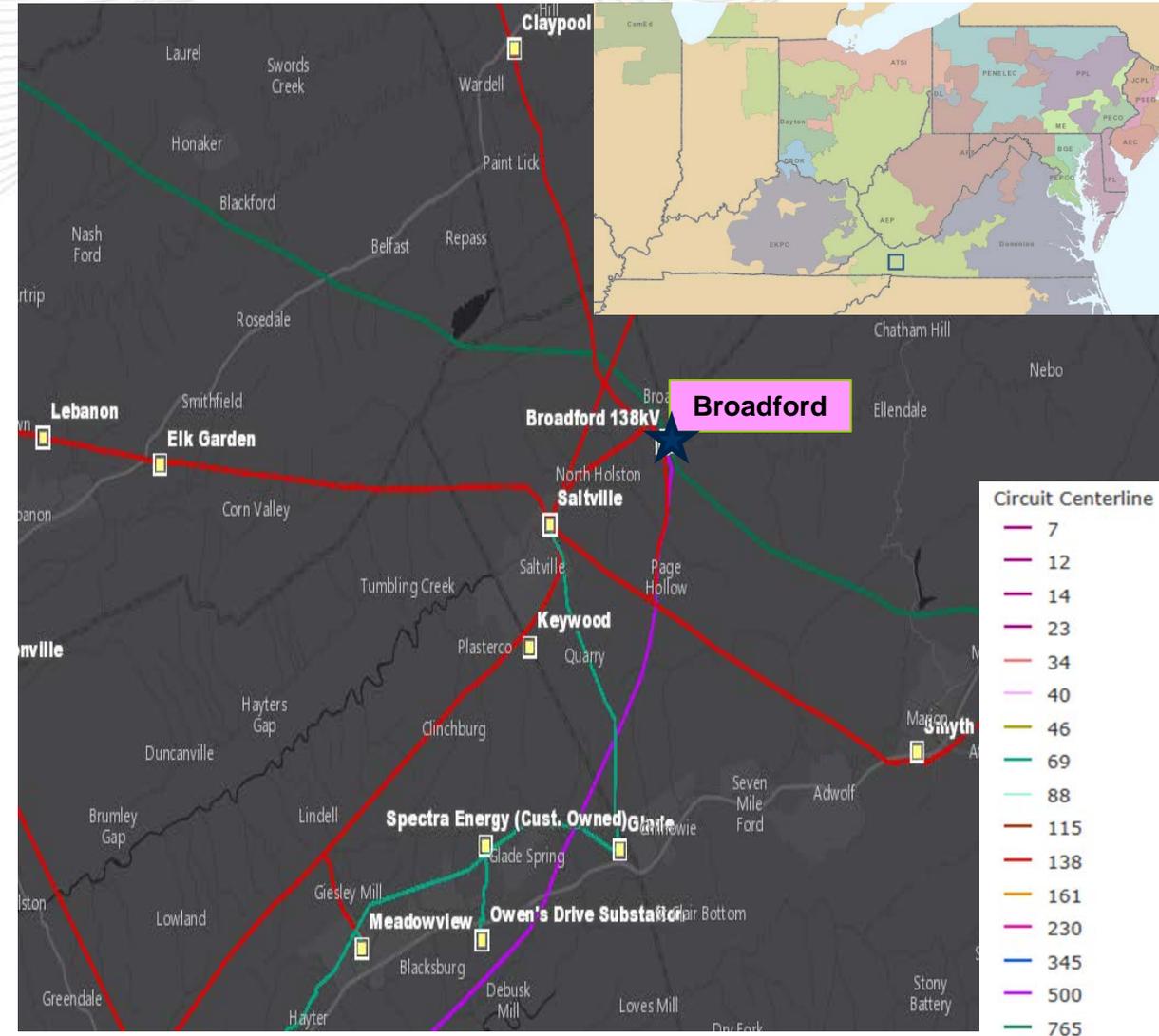
**Broadford 765 kV Yard:** Replace existing 765/138 kV 600 MVA XF #1 with a new 765/138 kV 750 MVA XF (standard size). Replace 765/500 kV 1500 MVA XF #4 with a new 765/500 kV 1500 MVA XF. Install one new 765 kV 4000 A 50 kA circuit breaker to complete the existing "P" string. Install two new 765 kV 4000 A 50 kA circuit breakers in a newly constructed "N" string. (S1462.1) **Estimated Cost: \$74M**

**Broadford 138 kV Yard:** Replace six existing 138 kV 3000 A 42 kA circuit breakers B, B1, B2, C, C1 and C2 with six new 138 kV 3000 A 63 kA circuit breakers. Install three new 138 kV 3000 A 63 kA circuit breakers in newly constructed D string. Replace existing 138 kV 3000 A 40 kA circuit breaker R with a new 138 kV 3000 A 40 kA breaker "CC". Replace existing 138 kV Reactor with a new 138 kV Reactor. (S1462.2) **Estimated Cost: \$28M**

**Total Estimated Transmission Cost: \$102M**

**Projected In-service: 12/01/2020**

**Project Status: Engineering**



## Supplemental Project

Previously presented: 12/14/2017

### Problem Statement:

#### Equipment Material/Condition/Performance/Risk/Operational Flexibility:

At Amos station, 765 kV circuit breakers 'U', 'U1' and 'U2' are 29 kA DELLE, PK-10D type air blast breakers that were manufactured in 1972. Air blast breakers are being replaced across the AEP system due to their history of catastrophic and violent failures. During failures, sharp pieces of porcelain from their bushings can be expelled from the breakers, resulting in potential safety hazards to field personnel. In addition, the ability to get spare parts is becoming increasingly difficult. Breaker 'U' has experienced 34 fault operations, breaker 'U1' has experienced 22 fault operations, and breaker 'U2' has experienced 26 fault operations. All of which are over the manufacturer's recommended number of fault operations (10). These breakers are being replaced with higher kA ratings in order to meet AEP's standard design for 765kV.

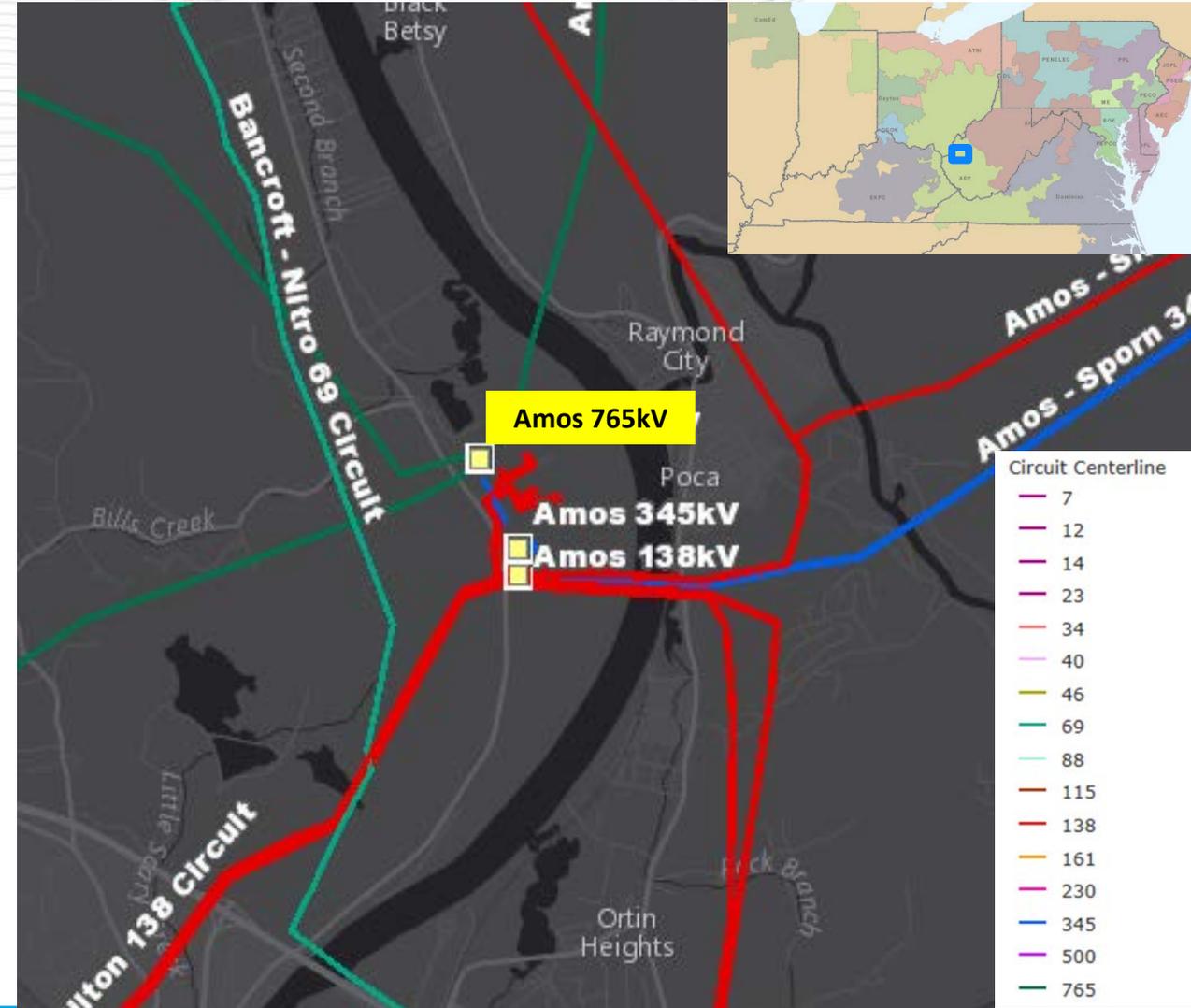
### Selected Solution:

Replace existing 3000 A 29 kA 765 kV circuit breakers 'U', 'U1', and 'U2' with new 4000 A 50 kA 765 kV circuit breakers. (S1463)

Estimated Transmission Cost: \$12.5M

Projected In-service: 12/13/2018

Project Status: Engineering



## Problem Statement:

- NOVEC is installing a 5th transformer at Brambleton DP and a normally-open 230kV bus-tie between the incoming feeds (from DVP's Brambleton 230kV Bus#1 and Bus#2).

## Selected Solution:

- Install all required protective relaying, metering, and associated equipment to accommodate NOVEC's 5th transformer and their ability to move load between the feeds from Brambleton 230 kV Bus #1 and Bus #2. **(s1460)**

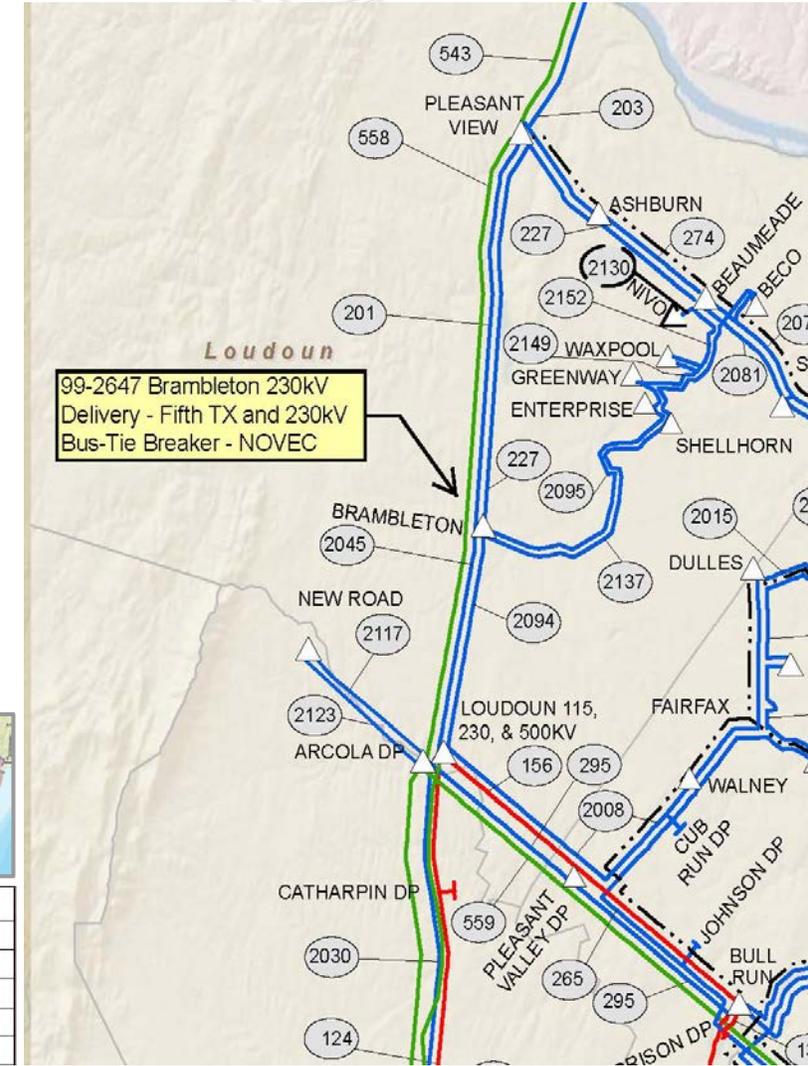
**Estimated Project Cost:** \$500 K

**Projected In-service Date:** 10/30/2018

**Project Status:** Engineering



COLOR	VOLTAGE	TRANSMISSION LINE NUMBER
Green	500 KV.	500 thru 599
Blue	230 KV.	200 thru 299 & 2000 thru 2099
Red	115 KV.	1 thru 199
Orange	138 KV.	AS NOTED
Cyan	69 KV.	AS NOTED



- PJM anticipates that all recommended baseline solutions in today's presentation (including the appendix) will be presented to the PJM Board in February and recommended for inclusion in the RTEP.
- Evaluation of the Roseland-Branchburg-Pleasant Valley 230kV line FERC 715 violation is continuing and the solution will not be presented to the PJM Board in February.

# 2018 RTEP Next Steps

2018

- 2018 RTEP Assumptions Review
  - TEAC – PJM assumptions today, 1/11/2018
  - SRRTEP – Local TO assumptions, see existing January 2018 meetings
- TEAC meetings are the following Thursdays in 2018
- **1/11, 2/8, 3/8, 4/5, 5/3, 6/7, 7/12, 8/9, 9/13, 10/11, 11/8, 12/13**

# Questions?



## Appendix:

# Previously Reviewed Baseline Upgrade Recommendations for the February 2018 PJM Board Review



# Baseline Reliability Mid Atlantic Region

### Generation Deliverability Outage

*Presented at the December 14, 2017 TEAC*

#### Problem Statement

Constitution – Concord 115 kV line is overloaded for the breaker failure contingency of MONUMENT STREET 110563/110558 BREAKER

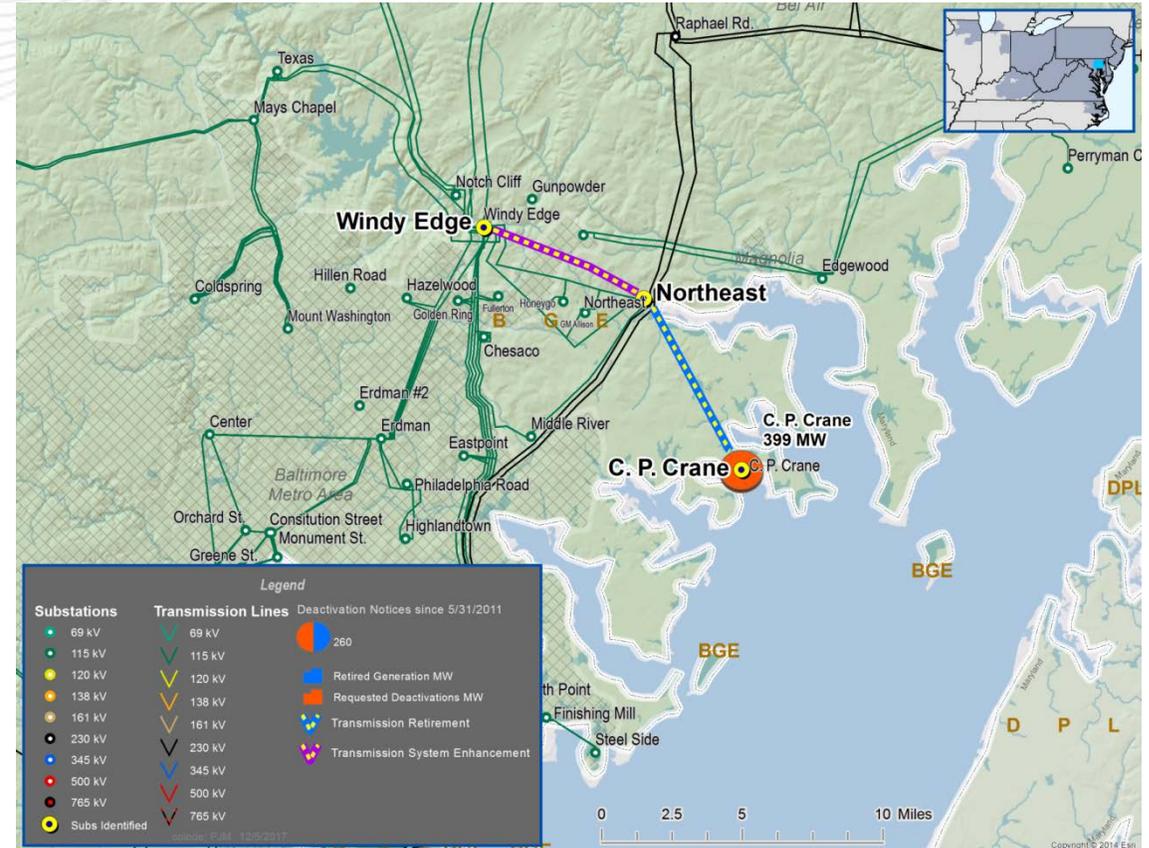
#### Recommended Solution

Re-connect the Crane – Windy Edge 110591 & 110592 circuits into the Northeast Substation with the addition of a new 115 kV 3-breaker bay. (B2816)

Cost estimate: \$ 6M

Required In Service Date: 06/01/2018

Projected In Service Date: 06/01/2019



### Short Circuit Violation

*Presented at the December 14, 2017 TEAC*

### Problem Statement

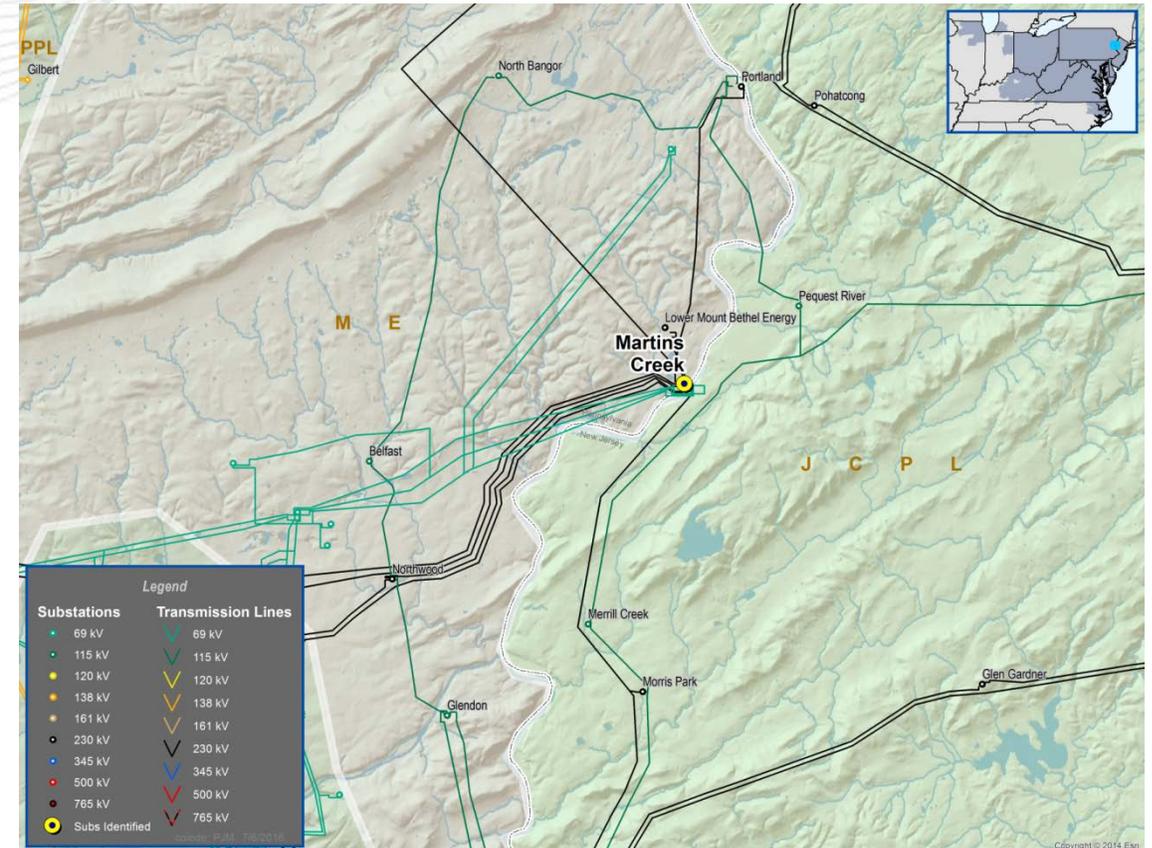
- The Martins Creek 230kV breakers are overdutied

### Recommended Solution

- Replace Martins Creek 230 kV circuit breakers with 80 kA rating. (B2979)

Estimated Cost: \$ 14.3 M

Required In Service Date: 06/01/2018



### TO Criteria Violation

Presented at the December 19, 2017 Subregional TEAC, Mid-Atlantic

### Problem Statement:

- PSE&G FERC Form 715: Hillsdale Substation is supplied by two underground 230kV lines. Hillsdale supplies more than 17,000 customers with load in excess of 80 MVA. An N-1-1 event would result in a complete loss of electric supply to the station for more than 24 hrs, a violation of PSE&G acceptable load drop levels and durations.

### Recommended Solution:

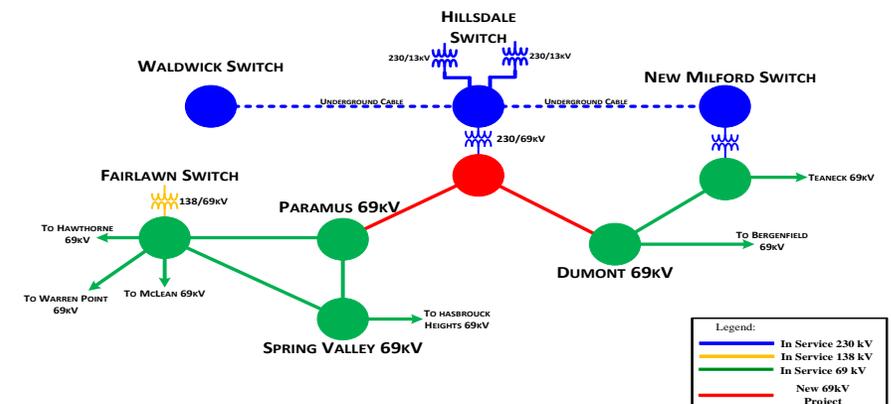
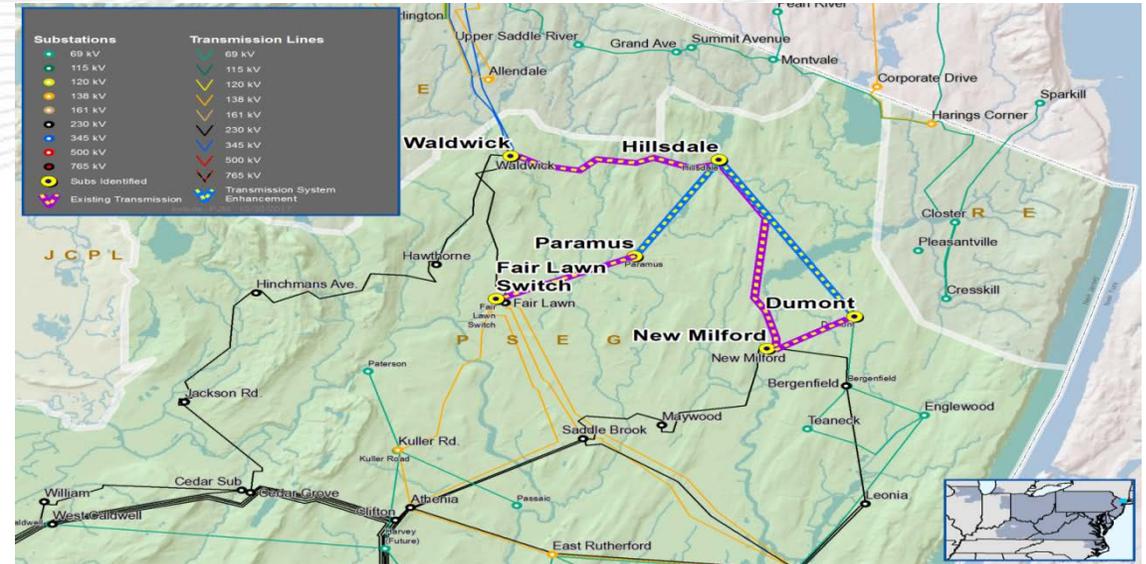
Construct a 230/69kV station at Hillsdale Substation and tie to Paramus and Dumont at 69kV. (B2982)

- Install a 69kV ring bus and one (1) 230/69kV transformer at Hillsdale. (B2982.1)
- Construct a 69kV network between Paramus, Dumont, and Hillsdale Substation using existing 69kV circuits (B2892.2)

Estimated Project Cost: \$115M

Required In Service Date: 6/1/2018

Expected In Service Date: 6/30/2021



### TO Criteria Violation

Presented at the December 19, 2017 Subregional TEAC, Mid-Atlantic

### Problem Statement:

- PSE&G FERC Form 715: Kuller Road Substation is supplied by two underground 138kV lines. Kuller Road supplies more than 18,000 customers with load in excess of 60 MVA. An N-1-1 event would result in a complete loss of electric supply to the station for more than 24 hrs, a violation of PSE&G acceptable load drop levels and durations.

### Recommended Solution:

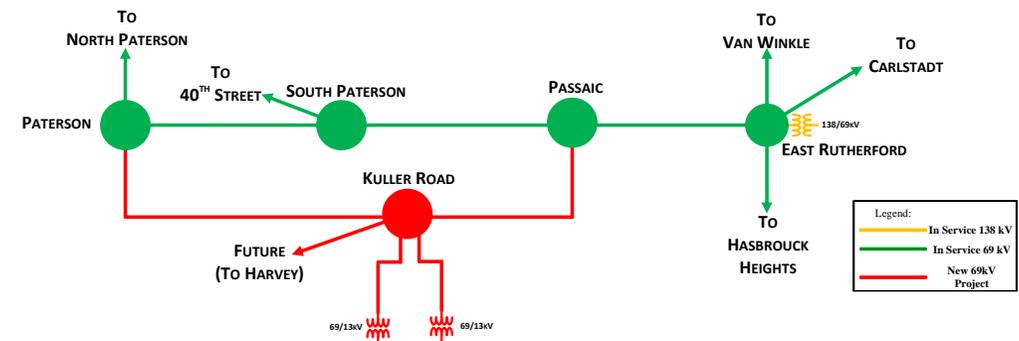
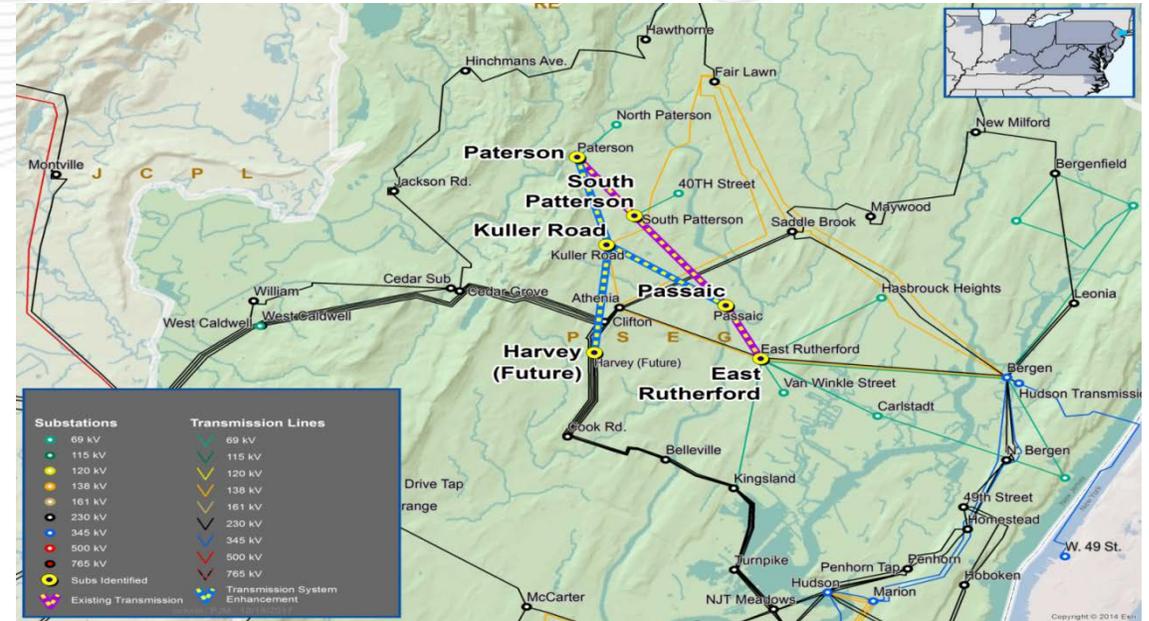
Convert Kuller Road to a 69/13kV station. (B2983)

- Install 69kV ring bus and two (2) 69/13kV transformers at Kuller Road. (B2983.1)
- Construct a 69kV network between Kuller Road, Passaic, Paterson, and Harvey (new Clifton area switching station). (B2983.2)

Estimated Project Cost: \$98.25 M

Required In Service Date: 6/1/2018

Expected In Service Date: 6/30/2021





# Baseline Reliability Southern Region

### TO Criteria Violation

*Presented at the December 18, 2017 Subregional TEAC, South*

Problem Statement: “End of Life Criteria”

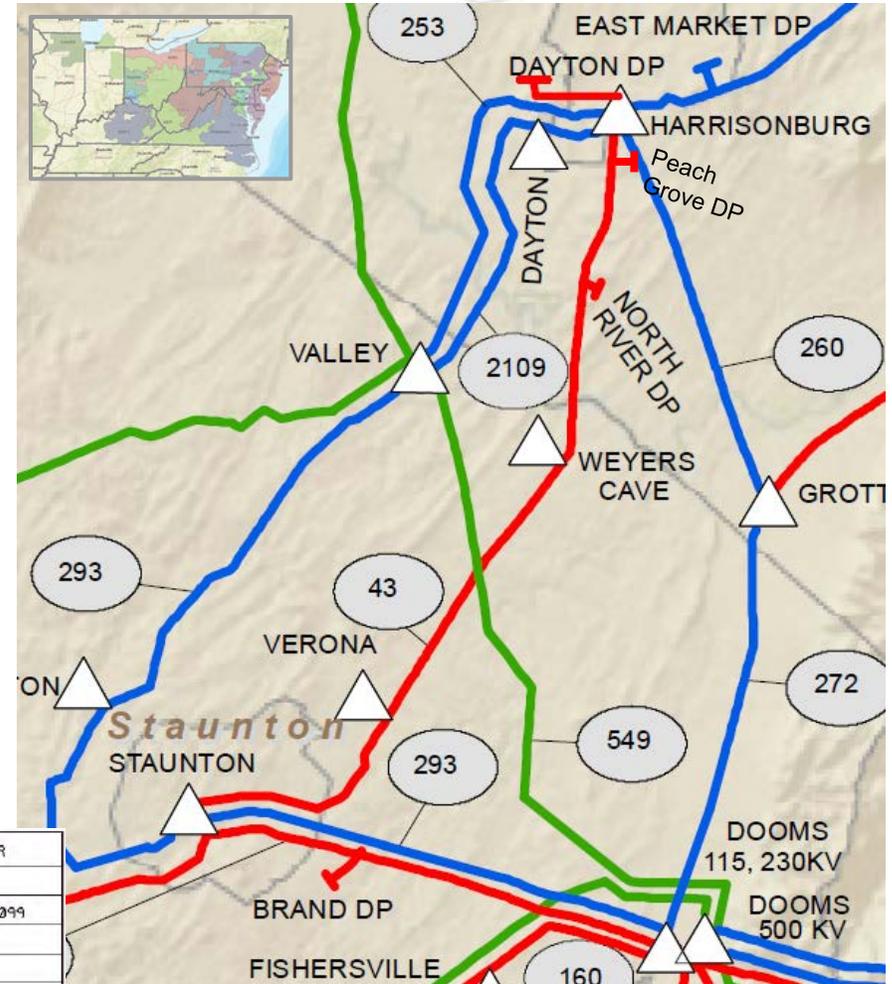
- 115kV Line #43 is approximately 22.8 miles long and was constructed on wood H-frame structures in 1958 from Staunton to Harrisonburg. This line has ACSR conductor and 3/8” steel static. This line serves Peach Grove DP, North River DP, Weyers Cave and Verona substations which encompasses 7,693 customers including 3,214 fed by Co-op. It has an existing summer emergency rating of 147 MVA between Harrisonburg and Verona. Between Verona and Staunton it has a rating of 168 MVA.
- Industry guidelines indicate equipment life for wood structures is 35-55 years, conductor and connectors are 40-60 years, and porcelain insulators are 50 years.
- Permanent MW load loss for removal of this line would be in excess of 58 MW. This line needs to be rebuilt to current standards based on Dominion’s “End of Life” criteria.

Recommended Solution:

- Rebuild 115kV Line #43 between Staunton and Harrisonburg (22.8 miles) to current standards with a summer emergency rating of 261 MVA at 115kV. (b2980)

Estimated Project Cost: \$37.5 M

Projected In Service Date: 10/31/2022



COLOR	VOLTAGE	TRANSMISSION LINE NUMBER
Green	500 KV.	500 thru 599
Blue	230 KV.	200 thru 299 & 2000 thru 2099
Red	115 KV.	1 thru 199
Orange	138 KV.	AS NOTED
Cyan	69 KV.	AS NOTED

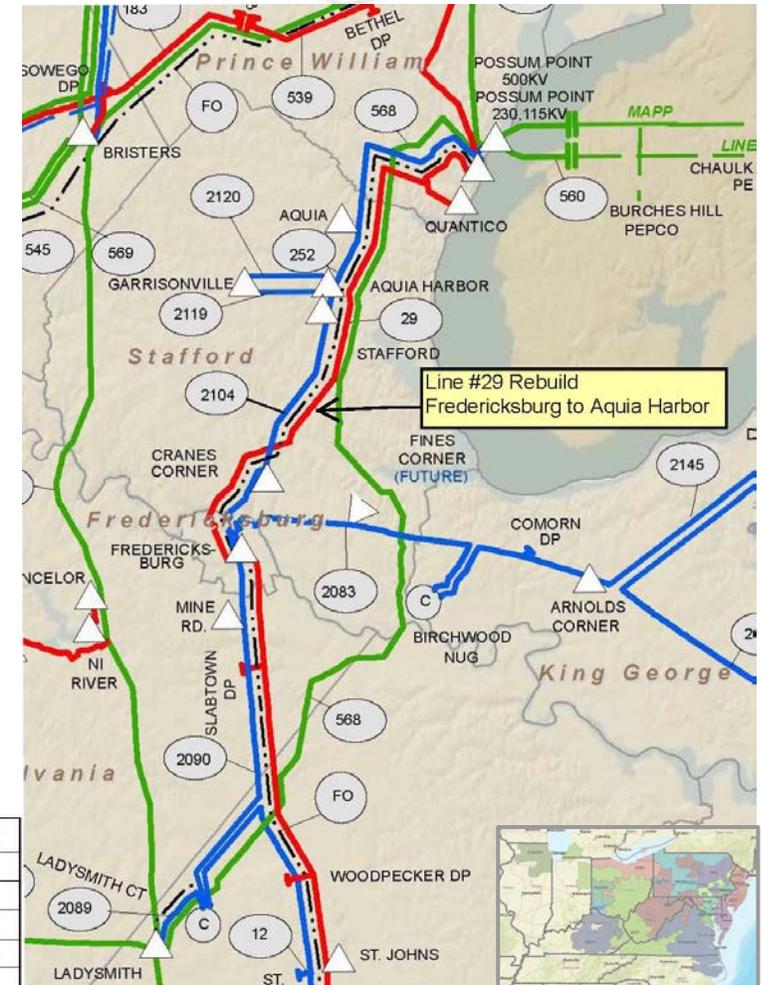
### TO Criteria Violation

Presented at the December 18, 2017 Subregional TEAC, South

#### Problem Statement: "End of Life Criteria"

- Total line length of 115kV Line #29 is 24.4 miles and runs between Fredericksburg Substation and Possum Point Power Station. The proposed rebuild segment of the 115kV Line #29 between Fredericksburg and Aquia Harbor is approximately 12 miles long and was constructed on wood H-frame structures in 1957. Existing conductor in the proposed rebuild segment is a combination of 1109 ACAR, 2-721 ACAR and 795 ACSR with a summer rating of 239 MVA. The remaining 12 miles of Line #29 is on a common 230kV lattice structure with Line #252 (with the exception of the tap to Quantico) with a summer conductor rating of 361 MVA at 115kV.
- This line provides service to Quantico Substation with a total of 440 customers including the Quantico USMC Base. Quantico Substation is connected to Line #29 with a 1.7 mile 115kV tap off the main line.
- Rebuilding this 12 mile segment of Line #29 to current 230kV standards (at 115kV) would be consistent with the Company's practice of containing the Northern Virginia area and would support the future conversion to 230kV with the remaining 12 miles already installed on 230kV structures.

COLOR	VOLTAGE	TRANSMISSION LINE NUMBER
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Orange	138 KV.	AS NOTED
Cyan	69 KV.	AS NOTED



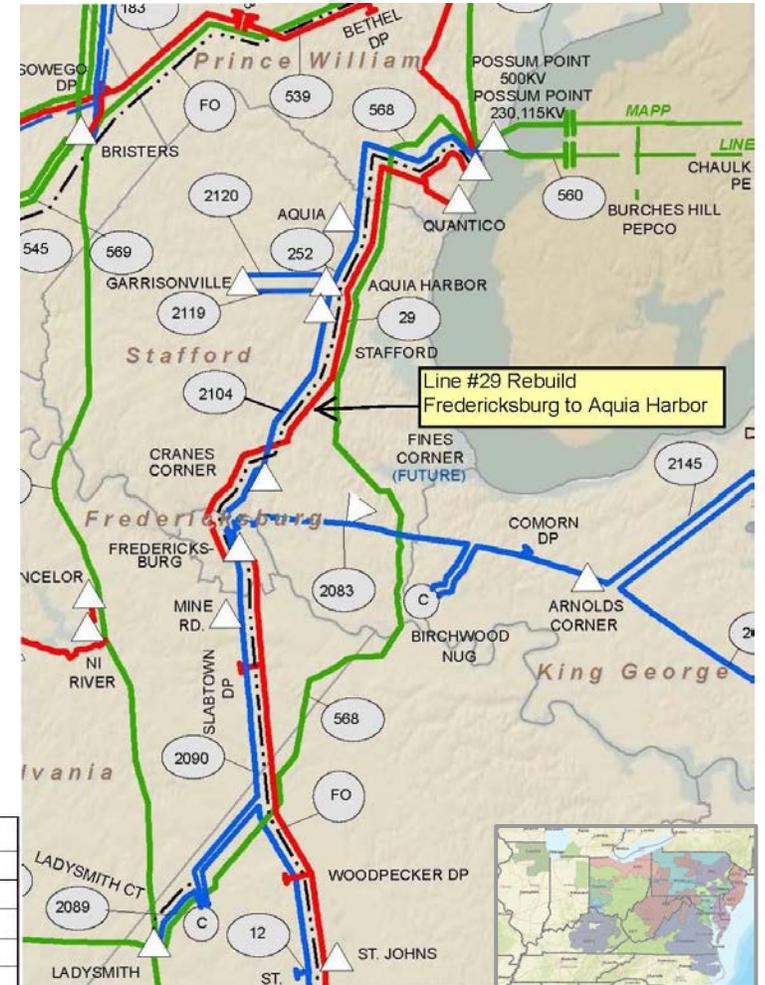
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Recommended Solution:

- Rebuild Line #29 segment between Fredericksburg and Aquia Harbor to current 230kV standards (operating at 115kV) utilizing steel H-frame structures with 2-636 ACSR to provide a normal continuous summer rating of 524 MVA at 115kV (1047 MVA at 230kV). (b2981)

Estimated Project Cost: \$12.5 M

Projected In Service Date: 12/31/2022



COLOR	VOLTAGE	TRANSMISSION LINE NUMBER
Green	500 KV.	500 thru 599
Blue	230 KV.	200 thru 299 & 2000 thru 2099
Red	115 KV.	1 thru 199
Orange	138 KV.	AS NOTED
Cyan	69 KV.	AS NOTED



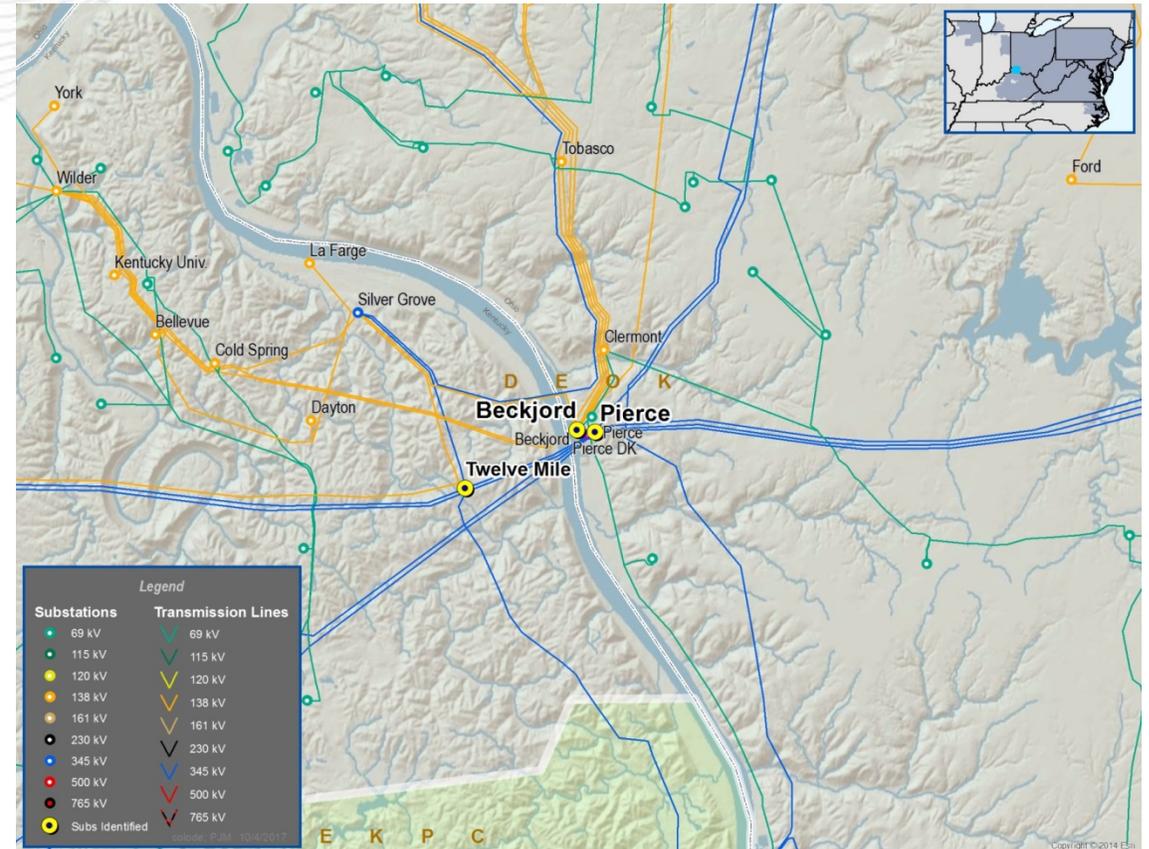
# Baseline Reliability Western Region

### Common Mode Outage and Basecase Analysis (Summer)

Presented at the December 14, 2017 TEAC

#### Problem Statement:

- The Pierce 345 /138kV transformer #18 is overloaded for the loss of the Pierce 345/138kV transformer #17 with the breaker stuck at Pierce.
- The Pierce 345 /138kV transformer #17 and the connected Pierce –Beckjork 138kV circuit are overloaded for the loss of the Pierce 345/138kV transformer #18 with the breaker stuck at Pierce.



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Alternatives considered:

- 2017\_1-6A (\$20.16M) :The two existing 345/138kV transformers that connect Pierce 345kV Substation to Beckjord 138kV Substation are fed radially. This project will Reconfigure Pierce 345kV Substation by adding new breakers, moving a feeder, adding a third 345/138kV transformer, and feed the Pierce-Beckjord transformers in a breaker and a half or double bus configurations. The three transformer feeds will be distributed across the three sets of buses at Beckjord.
- 2017\_1-2E (\$12.7 M): Build a 345 kV switching station ("Twelvemile") interconnecting the existing Silver Grove - Zimmer 345 kV transmission line and the Pierce - Buffington 345 kV transmission line.
- Portion of 2017\_1-6A (\$9.17M): Reconfigure Pierce 345KV substation and upgrade terminal equipment at Beckjord 138kV on the Beckjord – Pierce 138kV line

Project ID	Project Sponsor	2017 RTEP Window #1 target reliability flowgates solved?	Cost Analysis
2017_1-2E	NTD	Yes; But causes an N-1-1 thermal overload on the Beckjord – Pierce 138kV line (violation)	Estimated overall project cost by sponsor of \$12.7M (\$9.7 NTD scope + \$3M TO scope in current year) Cost cap = \$14M (in-service year \$'s) for NTD scope of work The fix for the new overload on the Beckjord – Pierce 138kv line is approximately \$1M;
2017_1-6A	DEOK	Yes, with no additional overloads	The submitted cost \$20.16M includes the Y3-064 merchant project cost, \$0.5M, which shouldn't be included as baseline cost, The total estimated cost is \$19.66M
Portion of 2017_1-6A	DEOK	Yes, with no additional overloads	The Estimated cost is \$9.17M. If the towers are not needed, it could lead to a cost reduction of \$1.25M from the total.

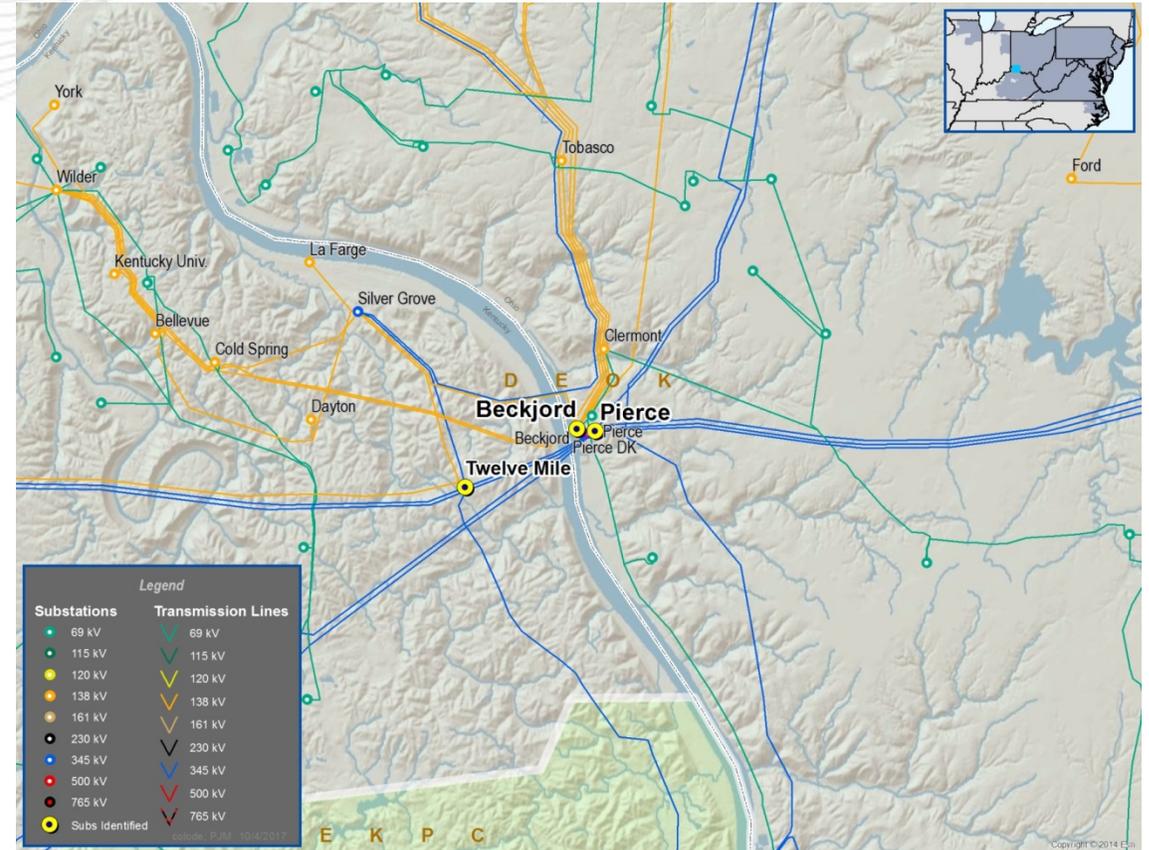
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Recommended Solution: (Portion of 2017\_1-6A )

- Install a new 345kV breaker “1422” so Pierce 345/138kV transformer #18 is now fed in a double breaker, double bus configuration. (B2977.1)
- Remove X-533 No. 2 to the first tower outside the station. Install a new first tower for X-533 No.2. (B2977.2)
- Install new 345kV breaker B and move the Buffington-Pierce 345kV feeder to the B-C junction. Install a new tower at the first tower outside the station for Buffington-Pierce 345kV line. (B2977.3)
- Remove breaker A and move the Pierce 345/138kV transformer #17 feed to the C-D junction. (B2977.4)
- Replace breaker 822 at Beckjord 138kV substation to increase the rating from Pierce to Beckjord 138kV to 603MVA. (B2977.5)

Estimated Project Cost: \$ 9.17 M

Required In Service Date: 6/1/2021



- V5 – 1/19/2018 – Added note slides 30 and 42 indicating the ongoing evaluation of the Roseland-Branchburg-Pleasant Valley 230kV line
- V4 – 1/12/2018 – Corrected Board date on Page 46.
- V3 – 1/10/2018 – Corrected annotation on graph on Slide 9. Updated cost information on Slide 16.
- V2 – 1/9/2018 – Corrected incorrect date on Slide 42
- V1 – 1/8/2018 – Original Slides Posted